Supplement to

INFORMATION LETTER

NATIONAL CANNERS ASSOCIATION

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Proceedings of the N.C.A. Technical Sessions at the 41st Annual Convention

ON the final two days of the 1948 Convention, January 20 and 21, three Canning Problems Conferences were held for discussion of subjects on the technological side of canning. The papers presented by the discussion leaders are reproduced in this Supplement to the INFORMATION LETTER of January 28 (Convention Issue). In all, 13 papers were presented on 11 general topics, each presentation being followed by questions from the floor and full discussion. The papers are grouped and published in the same general sequence in which they were presented at the conferences, and all of them are reproduced in full. Copies of this Supplement are being mailed to all canner-members. Additional copies will be available on request, and it also is planned to make available separate reprints of the individual papers for those who prefer them in that form.

NEW AND OLD PROBLEMS IN FORMULATION OF STANDARDS FOR CANNED FOODS

By Joseph Callaway, Jr., Food and Drug Administration, Federal Security Agency

The authority granted in the Food, Drug, and Cosmetic Act to adopt standards for various foods has been in effect for over nine years. Conditions during several of these years were abnormal; at times we had an opportunity to observe the effect of food standards in periods of food scarcity. Since 1938 we in the Food and Drug Administration, and you as food manufacturers, have had considerable experience with the formulation and application of food standards, under both normal and abnormal conditions.

The procedure provided under authority of the Food, Drug, and Cosmetic Act for the adoption of food standards is somewhat unusual. A good deal has been written about it from the legal standpoint. Much of this comment has not been complimentary. In my opinion, the basic procedure, though time-consuming, is sound. At present, however, I do not want to discuss legal procedure, good or bad, but to consider what I believe to be more important—that is, what should we do to make sure that our food standards are as good as it is possible to make them?

Undoubtedly there are differences of opinion as to what constitutes a good standard, and even greater differences as to what may be considered the best. I believe it very desirable for food manufacturers to understand our point of view as to what constitutes a good standard, and likewise for us to understand theirs. This is particularly true about certain points in the formulation of food standards.

Problem of Identity vs. Quality

Now, as you know, at present the Food, Drug, and Cosmetic Act authorizes the adoption of three kinds of standards—identity, quality, and fill of container. Theoretically the distinction between the different kinds of standards is definite. In practice it is often hazy.

Definitions and standards of identity are related closely to our old standards of purity. Identity for the purposes of the Food, Drug, and Cosmetic Act is a somewhat different concept than identity as defined in the dictionary. With the authority to adopt a definition and standard of identity goes the authority to require label statements of optional ingredients. In several instances this point has precipitated controversies. Broadly speaking, the name of a food establishes its identity with some degree of certainty.

When a definition and standard of identity is established for a food, it becomes necessary to determine whether its identity shall be confined to a narrower range than that of existing commercial practice. Variations due to the use of optional ingredients usually can be provided for by appropriate label statements. We should be careful to include in a standard, or to provide a separate standard if necessary, for variants which are legitimate and which are in harmony with consumer interest.

We have no acute problems of this kind at present with canned foods, although we do have this kind of situation with canned unpeeled tomatoes. The definition and standard of identity for canned tomatoes prescribes that they be peeled and cored. Imperfect peeling causes them to be substandard in quality. Sometimes tomatoes, particularly the small pear-shaped varieties, are canned unpeeled. At present such unpeeled tomatoes are labeled substandard in quality. This situation needs correction.

Problem of Optional Ingredients

It is customary for a definition and standard of identity to provide that the names of certain specified optional ingredients be stated on the label. A related problem is to prevent such a label statement unless there is

enough of the optional ingredient present to justify naming it on the label. For example, suppose a definition and standard of identity for canned grapefruit juice is being considered.

In considering optional ingredients the question arises as to whether sugar should not be made an optional ingredient with requirement for label statement when used. However, if the label states "Sugar Added," it likely conveys the impression that the juice is sweet, and in our opinion a product so labeled should have enough sugar to be definitely sweet. Merely listing sugar as an optional ingredient is hardly enough to control the situation.

Better Understanding Needed

An identity standard which met with rather a cool reception from the canning industry was that for canned green beans. This food had been included hitherto in the omnibus standard for canned vegetables. When the quality standard was adopted, however, a separate identity standard also was provided. Much of the criticism of this identity standard has had to do with an attempt in it to require some suitable label statement of cut beans consisting mainly of end pieces from vertical packs or end pieces removed by so-called "nubbin" graders.

The situation is complicated by the fact that some canners are packing a special, very short cut bean, where the pieces are all of uniform length. Identity and quality are hard to separate here. The short cuts of uniform length were handled by being made an optional form of bean ingredient in the identity standard. An attempt was made to provide a substandard quality label for the mixtures containing large numbers of short pieces.

Soon after this standard was promulgated, there was an application for a hearing to take evidence on proposals to amend. The Administrator has signified his intention to call such a hearing. Both canners and the Administration have been accumulating data which will be helpful in clarifying the issues.

From my experience with this standard, I believe that prior to the first hearing the Food and Drug Administration did not understand the viewpoint of the canners, and the canners did not understand what the Food and Drug Administration was trying to do in correcting what were believed to be abuses. I am sure we all want to avoid such situations. We would like your suggestions as to how it can best be done.

Problem of Quality Standards

Quality standards raise as many if not more problems than identity standards. Since all of the quality standards so far adopted have been for canned foods, you have shared our troubles. The grant of authority with respect to the adoption of quality standards is to a large extent an inheritance from the McNary-Mapes amendment to the Food and Drugs Act of 1906, and some of the difficulties in utilizing quality standards under the Food, Drug, and Cosmetic Act are due to the fact that authority is granted to make only one quality standard for a food.

The McNary-Mapes amendment was enacted at a time when the production of canned foods met and sometimes exceeded the demand. It was believed then by many that the presence on the market of products of poor quality was retarding the sale of canned foods in general, and that both consumers and manufacturers would benefit by a law requiring that canned goods of low quality bear a distinguishing label. There was little intention, as I understand it, of encouraging the consumer to buy the low quality products at a price, but it was intended to discourage the packing of such products. There was some precedent in a California law requiring canned fruits of low quality to be labeled "Seconds."

When the amendment became effective and quality standards began to be set up, canners generally wanted the "minimum quality standards," as they began to be called, to be established so that where the quality of a canned food fell below the commercial grade known as "standard," it would be required to be labeled as "Substandard" or "Below Standard." This, with possibly some minor exceptions, was the basis for the quality standards adopted under authority of the McNary-Mapes amendment.

Problem of Quality vs. Grade

Generally speaking, grade standards are based on the theory that the "standard" grade is about as low in quality as is generally considered salable, so the substandard quality designation indicating a lower quality has had almost the same effect as making foods in this category unlawful, since canned food distributors are generally unwilling to handle them.

Now, in periods of scarcity, food manufacturers are very loath to advocate a quality standard which will interfere with sales of edible foods. This brings about a situation tending to encourage placing the substandard quality level almost at the inedible state. Since the Food and Drug Administration has no part in making grade standards, we always cannot agree that the bottom of the commercial "standard" grade should automatically become the top of substandard quality under the Food, Drug, and Cosmetic Act.

Since variations in quality are bound up with natural foods and frequently depend on differences of quality in natural products, the need for quality standards is probably more keenly felt with canned fruits and vegetables than with any other foods.

We should like to explore the possibility of applying quality standards under the Food, Drug, and Cosmetic Act so that they would not make the food unsalable, but salable for what it is. We certainly will need your cooperation in this exploration.

Objective Tests Needed

To add to the difficulties in formulating quality standards under the Food, Drug, and Cosmetic Act, there is the need of devising objective tests so that the determination of whether or not a food complies with a quality standard is not based on mere personal opinion. Chemists in the canning industry have made valuable contributions to the development of suitable objective tests. Our combined efforts are needed to continue to make progress.

Is Nutritive Value a Quality Factor?

So far, no quality standard has included nutritive value as a quality factor. Many people believe that in the case of a few foods, at least, nutritive value should be so considered. For example, many consumers buy tomato juice, orange juice, and grapefruit juice because they believe these foods are good sources of vitamin C. Now, as you know, these juices, particularly tomato juice, vary greatly in vitamin C content. Possibly, it may be desirable to include vitamin C content as a quality factor in the standards of quality.

Need for Clearer Concepts

I feel that in the field of quality standards, there is the greatest need for developing and improving our concepts. There has been a very rapid development in the adoption of grade standards. Most of these are based on the theory that a grader can fix in his mind the appearance and the taste of a normal product without defects, and can grade down on various points which detract from appearance and eating quality. Unquestionably, grade standards serve a very useful purpose to producers and dealers in foods of many kinds.

We have attempted to use in quality standards under the Food, Drug, and Cosmetic Act many of the factors which cause down-grading. Most of them have to do with appearance. One of the most difficult to deal with is visual blemishes. I believe you are now experimenting with color photography to illustrate blemishes. I hope this will eventually lead to a better understanding of what different people call a blemish. From there it may be possible to go further and

improve the provisions in quality standards with respect to blemishes.

If the eating quality of a food is satisfactory, consumers are often inclined to be less exacting as to its appearance. On the other hand, if a food looks fine and is edible, many dealers consider it to be of high quality. Some quality standards under the Food, Drug, and Cosmetic Act and many grade standards attempt to insure good eating quality by making this factor synonymous with some degree of maturity of a fruit or vegetable.

Even where there is a close relation between maturity and eating quality, it is about as difficult to define and measure maturity objectively as to define and measure eating quality. In my opinion, eating quality has not been given as important a place in quality standards as it deserves. This is probably due to lack of accurate methods of measurement.

Now to return to the question I mentioned a few moments ago—"Should an excellent rating in some quality factor offset a low rating in other factors?" I am inclined to believe the answer is "Yes," but I do not know just how the application of such a principle should be made.

Problems on Fill of Container

I might discuss other problems waiting to be solved in connection with quality standards, but I have mentioned some that are of interest to us at this time, and should like to say a little now about problems connected with standards of fill of container.

Until recently I had looked upon fill of container standards as relatively simple. For many years the basis for requirements for proper fill of containers has been the principle set out in a notice with respect to canned foods, issued by the Secretary of Agriculture in 1912 as Food Inspection Decision 144. The relevant part of this notice has been quoted many times but will, I believe, bear repetition.

"The can in canned food products serves not only as a container but also as an index of the quantity of food therein. It should be as full of food as is practicable for packing and processing without injuring the quality or appearance of the contents. Some food products may be canned without the addition of any other substance whatsoever, for example tomatoes. The addition of water in such instances is deemed adulteration. Other foods may require the addition of water, brine, sugar or sirup, either to combine with the food for its proper preparation or for the purpose of sterilization—for instance peas. In this case the can should be packed as full as practicable with the peas and should contain only sufficient liquor to fill the interstices and cover the product. Canned foods therefore will be deemed to be adulterated if they are found to contain water, brine, sirup, sauce or similar substances in excess of the amount necessary for their proper preparation and sterilization."

Putting this principle into effect raised a number of practical problems. One of the first was whether it was possible to establish a numerical minimum limit on the drained weight of a canned food so that cans not meeting this limit would be considered slack filled. The Bureau of Chemistry set out to do this for a number of canned fruits and vegetables where water or sirup was used as a packing medium. Vegetables on the whole lent themselves better to this type of treatment than fruits. Oysters, clams and shrimp also were studied and suggested minimum drained weights published. These suggested limits served a useful purpose for many years.

Concept of Standard Fill

With the McNary-Mapes amendment, efforts were made to place fill of container standards on a simple and logical basis. The following general requirement applicable to all canned foods was promulgated:

"Canned food is of standard fill when neither the head space nor the amount of water, brine, sugar solution or other packing medium is excessive."

You will recognize the similarity to F.I.D. 144. Realizing, however, the need for more definite requirements when possible, the fill of container standards for canned peaches, pears, apricots and cherries contained more specific requirements. For instance in the case of canned peaches the standard of fill contained the following:

"Added liquid is excessive in canned peaches when the weight of the fruit placed in the container is less than 60 percent of the weight of water which the sealed container will hold at 68° F., with, when necessary to prevent crushing of the fruit, a tolerance not exceeding the weight of one average piece."

The requirement specifying put-in weight had some obvious disadvantages in enforcement work, and prior to adoption of the fill of container standard for canned peaches under the Food, Drug, and Cosmetic Act, a great deal of experimental work was done with the hope that a standard of fill of container could be established based on drained weight. This work showed that the relationship of put-in weight to drained weight was affected by a number of factors.

At the time the standards for canned peaches under the Food, Drug, and Cosmetic Act were adopted, it appeared that no numerical drained weight requirements were practicable. The same difficulties were encountered with canned pears, apricots and cherries. Since that time some additional work has been done on the problem, but much more is needed if minimum drained weights are to be specified. The present requirements have served a useful purpose but there is much room for improvement.

Problem of Standards of Fill for Shrimp and Oysters

A difficult problem in determining what fill of container will promote honesty and fair dealing has arisen in connection with the fill of container standards for canned shrimp and canned oysters. As you probably remember, in order to obtain tin for canning these foods, canners and the War Production Board in 1942 agreed on greatly increased fills. After these fills had been shown to be satisfactory, they were embodied in fill of container standards under the Food, Drug, and Cosmetic Act, except that the fill of container standard for canned oysters did not apply to the very large oysters packed on the Pacific coast.

After revocation of the tin conservation order, shrimp and oyster canners wished to return to the old fills. How could it be in the interest of consumers to replace oysters or shrimp with water? You can readily see the problem. Hearings have been held. Final decisions by the Administrator had not been made at the time this is written.

Whole Kernel Corn Presents Interesting Problem in Establishing Standard

A current problem which brings out another interesting point is what is the proper basis for establishing a standard of fill of container for canned whole kernel corn. A mechanically operated filler for packing this food has been developed and is in general use. This fills the corn into the can by gravity flow in the same way that cans of peas are filled. Kernels of corn, however, do not flow freely and adjust themselves evenly in a can as does a liquid or even as well as peas. Hand-filling cans with corn with gentle pressure can give a can of much higher fill and apparently of equal or better quality. The question arises, "Is it reasonable and desirable to consider a standard of fill of container which would call for the development of a more efficient filling device?"

Good Standards Based on Cooperation

In this short paper I have attempted to bring up questions or topics for further consideration rather than attempt to supply the answers. The canned food industry and the officials enforcing the Food and Drugs Act of 1906 and later the Food, Drug, and Cosmetic Act, have worked together to solve similar problems over a period of nearly 40 years. Since the Food,

Drug, and Cosmetic Act of 1938 became effective and gave a legal status to what had previously been advisory announcements, there has been a tendency on the part of some canners to view with alarm the proceedings leading to the adoption of standards, and some canners have shown apprehension as to the probable effect of the application of legal standards.

To what extent this may be justified, I do not know. Much of the apprehension, I believe, is due to a lack of understanding. This can and should be overcome. I believe we can all agree that the interest of canners as well as consumers will be served best by good standards, and I believe that you, like myself, feel that the best way to get good standards is to work together toward that end. Your cooperation in the past has made our present standards possible. We want even more of your cooperation in the future.

WHAT'S BEING ACCOMPLISHED BY PLANT SANITATION
1. An Industry View

By R. E. Sanborn, California Packing Corporation

The answer to this question is obvious and quite generally known in the industry, when considered in its narrower sense. We are packing cleaner, better products, our labor is functioning under more pleasant operating conditions, with consequent greater efficiency, our accident records are improved, and we are actually saving money over previous operating experience.

Nevertheless, most of us have made only a good start, some of us not even that, many of us are far from appreciating the fundamental principles underlying the program. The activity of the National Canners Association originally was stimulated by the U. S. Food and Drug Administration, through the announcement that the clause in the act which they administer, providing that food "may be considered adulterated if it is packed under unsanitary conditions, whereby it may have become contaminated," would in the future be a specific subject for regulatory action.

Many of us still contemplate sanitary improvements in fear of the policeman, not appreciating fully the broader view that great benefit is to be derived from the production of esthetically more desirable products. At the same time the actual savings in operating cost are frequently not recognized—direct savings because it is easier to keep a plant clean than to clean it up after neglect, and indirect savings because desirable working conditions result in a contented operating crew with some pride in their work and hence more efficiency, less accidents, and less waste.

Value of Right Approach

I choose to speak particularly of accomplishments in the broader sense, for to me, this is the far more revolutionary concept. Most of us have been more or less conscious of the advantage of clean plants and have endeavored to maintain them. In fact, a cautious first approach to the subject of sanitation is important, for many operating men are resentful of criticism, however constructive, until they begin to appreciate the benefits of the program and the value of observation and constructive criticism by trained personnel. However, such resentment is well worth the effort necessary to dispel it, for this very resentment is evidence of the personal pride of the individual in the plant, who usually "gets religion" promptly and becomes an enthusiast.

Sanitation Linked to Other Factors

The greatest accomplishment we can record today is the result of the educational efforts of the National Canners Association. Thousands of men in our industry today are thinking consciously of their operations with reference to the sanitation concept. The important matter is to keep this subject fresh and interesting, to make its value constantly and increasingly obvious. There is danger that we shall become smugly satisfied, cease to progress, and eventually forget *why* we do *what* we do.

It is inevitable that thought and action in the field of sanitation should stimulate—even initiate—thought along lines of which sanitation is only one of numerous aspects. Thus, the design of cannery floors in accord with sanitary engineering principles will produce a well-drained, approximately dry floor, which subsequent sanitary practice will keep free from slippery surface. The result is minimization of accident hazards, and a surface over which employees may walk and trucks be operated safely at relatively high speed.

The disposal of solid and liquid waste is perhaps only incidentally connected with sanitation, yet this line of thought usually will turn to ways and means of reducing the volume of waste, handling by methods designed to minimize the problems of waste disposal including costly procedure, and frequently the pollution of rivers or ground water supplies.

Cannery Lighting a Part of Sanitation

It may be doubted that the National Canners Association project for the study of cannery lighting conditions would have been financed generously without any opposition had it been proposed prior to the conditioning of industry thought through contemplation of plant sanitation. Yet sanitary inspection is only an incident of cannery lighting, when compared with the other seeing tasks, such as sorting, manual control of machinery, and truck operation.

Responsibilities of Sanitarians

Cannery employees trained to consider cannery operation from a sanitary standpoint in the National Canners Association Training Courses or elsewhere—in foremen's meetings or informal discussions—usually are successful in arousing general interest and new ideas. Committees are excellent for this purpose and for bringing to bear the combined experience of an organization. However, it must be one man's job to see that such groups function and that thought is translated into action. Combining the sanitarian's job with other work is a satisfactory arrangement for creating a full-time job, providing that responsibilities connected with day-by-day production do not encroach on his time to the point where sanitation is neglected. Sanitation must be the sanitarian's major objective. The best combination is with other staff work, particularly with accident prevention and fire protection. He should have time for careful observation, thought and planning. His responsibility should be to the chief executive of the plant organization, who in turn should cause the execution of changes in construction or in plant operating practice that may be indicated.

Professional Status of Sanitarians

An accomplishment already of considerable importance, but more important for its future promise, is the recent formation of the Association of Food Industry Sanitarians. Two years ago at the instance of the National Canners Association and the California State Board of Health, the University of California organized a training course for sanitarians of the canning industry. Most of the students enrolled in this course were men with cannery experience, and in addition having some measure of scientific education. One important part of this training course was the development of a manual of plant sanitation comprising the best judgment and experience available at that time for application of the principles of sanitary science to cannery operation. This manual was prepared as what might be termed a thesis, and all of the enrolled students collaborated in its preparation under the guidance and with the assistance of the faculty.

The men who successfully completed this course formed the nucleus of the Association of Food Industry Sanitarians, whose membership now is being extended to include other properly-

qualified sanitarians in the industry. Founded for the initial purpose of revising the manual in the light of experience, the Association now proposes to be a medium for the dissemination of information and an open forum for discussion of matters relative to sanitation, such as design of machinery, detergents and equipment for their application and in-plant chlorination. Thus, in their special field, they propose to apply a cardinal principle of the National Canners Association: to promote constructive discussion and the exchange of ideas for the improvement of the industry.

Surely, the establishment of the canning industry on an ever-higher plane of cleanliness and general excellence is a worthy ideal toward which to bend all our efforts. The sanitation program has provided a strong stimulus to this end. Accomplishment alone fully justifies the program.

WHAT'S BEING ACCOMPLISHED BY PLANT SANITATION

2. The N.C.A.'s Contribution

By Ira I. Somers, National Canners Association Western Branch Laboratory

For nearly three years the Laboratories of the National Canners Association have been engaged in a program of service to the industry in the field of factory sanitation. During the same time, there has been evident an increase in industry awareness of sanitation problems and interest in the application of scientific methods of sanitation.

It would give a distorted picture merely to describe the N.C.A. program out of relation to developments within the industry and without mentioning the contributions of service industries. Therefore, the first step will be to indicate some of these industry developments, and the second to show how the N.C.A. program has dovetailed with them.

In describing the latter, discussion material will be drawn from the experience of the Association's Western Branch Laboratory, simply because that is the phase most familiar to the speaker. The general approach to the sanitation program has been similar for both the Western Branch and Washington Laboratories, differences in detail being such as were dictated by the distribution of the industry and local circumstances.

Contributions of Plant Sanitarians

The accomplishments of the sanitation program have been numerous, and to those closely associated with it, most gratifying. Many valuable improvements in methods of handling, preparing and safeguarding foods have appeared, and there has developed within the industry a wide sanitation consciousness which continues to act as a strong stimulus for still further improvement.

Probably the greatest individual contributions to the improvement of plant conditions will continue to be made by those men in industry actively engaged in sanitation. Over 100 such men with special training now are in the western region. While their contributions have been many, only a few of the outstanding developments can be mentioned here.

One development which has resulted in considerable improvement is that of giving the sanitarian the responsibility for approving purchases of machinery, cleaning materials and tools, germicidal agents, insecticides, etc., and supervising pest control services. The value of this program is that it places under the sanitarian's supervision factors directly affecting sanitation. This has resulted in great improvements in purchasing practices in plants where purchases previously were made by office-trained purchasing agents. It often results in considerable savings and prevents the purchase of unnecessary or ineffective supplies.

Some sanitarians have instituted "sanitation committees" to function for sanitation very much as safety committees do for safety. Closely allied to this are in-plant sanitation training programs which several sanitarians now are using as a means of stimulating improved employee sanitation practices. These programs have been highly successful.

An interesting method of stimulating an awareness of sanitation among employees has been developed by another sanitarian having several plants under his supervision. He has instituted a system of sanitation ratings, by which he classifies each plant in a manner similar to that in which restaurants are rated in certain areas. The rating given is based on improvements made and the general sanitation conditions of the plant at the time of his visit. Such a plan serves as a strong stimulus for improvement, setting a goal of attainment by comparing each plant with others.

To serve as aids in the presenting of educational programs, many photographs have been taken of plant conditions by both plant sanitarians and National Canners Association personnel. As a result, a number of pictures portraying various plant conditions have been accumulated. One sanitarian has made available to the Association a complete series of color photographs on plant construction and cleanup. These pictures have served as invaluable aids in training programs.

Periodic plant surveys are being used by some sanitarians as their means of stimulation and evaluation. These surveys serve to focus the employee's attention on sanitation and, by means of the reports, the manager is constantly informed of the plant's sanitation status and needed improvements.

In addition to organizing sanitation improvement programs, plant sanitarians have been responsible for many structural improvements. Under the supervision of a sanitarian, a new plant was completely equipped with machinery having sanitary tabular supporting members. Many others have made considerable headway in the construction of buildings and equipment incorporating principles of sanitary design, leading to more economical operations and efficient maintenance. Much also has been accomplished by replacing insanitary piping that presented cleaning difficulties and spoilage hazards with stainless steel and glass piping of sanitary design.

The improvements in clean-up tools and methods are among the more outstanding contributions made by plant sanitarians. There has been a wide acceptance of high-pressure units and steam guns. Brushes have been altered so as to clean more effectively. Some sanitarians are determining the relative value of different detergents by rating them according to their ability to remove deposits in the plant concerned. Many operators have noted improvements and savings by placing the responsibility for the clean-up on a first-rate foreman with a trained and well equipped crew. Several companies have adopted in-plant chlorination of their water supply as an aid in maintaining cleaner plants by preventing slime and bacterial growth on equipment and eliminating unpleasant odors.

The control of insects and rodents has been, and still is, one of the major problems confronting many canners. However, by the same continuous effort that has resulted in the solution of other problems, sanitarians have been able to bring these under control. Rodents have been eliminated by building out, destroying harborages, and trapping or poisoning; and insects have been controlled through the elimination of breeding sites and the use of DDT or other new insecticides.

The success of the sanitation program within the plant is determined largely by the sanitation staff and the extent of individual capabilities and responsibilities. This staff may vary from plant to plant, but in general it has been found that quality control men or other supervisors are able to carry the program capably after being trained in the fundamentals of sanitation. In some large organizations, sanitation requires the full time of

one man, but in most plants men have been able to assume sanitation duties in addition to their other responsibilities by obtaining assistance and rearranging their duties.

Role of Machinery Manufacturers

An awareness of sanitation among canners is creating new problems for machinery manufacturers. In the past they have considered primarily three factors in the construction and sale of equipment: The cost of competitive equipment, the functional efficiency of the machine, and the durability, or rate of depreciation. Now, as a result of the canner's realization of the advantage of sanitation, they must consider also the relationship of necessary features of construction to dead ends, stagnant areas harboring contamination, and the relative ease with which the machine can be cleaned to comply with the present concepts of sanitary cleanliness. In some cases this may be easy, but in many instances a complete redesigning of equipment will be necessary. The more progressive manufacturers are facing the problem squarely and improvements are under way. However, there is still a reluctance on the part of some to alter their designs until canners have been sufficiently well educated in sanitation principles to accept the additional manufacturing costs as necessary and to pay for equipment based on a consideration of all these factors.

There seems to be a real desire among equipment manufacturers to acquaint canners with all the cost factors in the purchasing of equipment. One problem which they have recently called to the attention of the industry is that there may be very little relationship between the initial cost of the machine and the cost per unit of product handled, the reason being that the over-all cost per unit is often determined largely by cost of operation, depreciation, and clean-up. Thus, equipment that is more expensive to buy but easier to clean, and is made of durable material, may be much cheaper in the long run.

There is on the market at the present time much equipment that is unsanitary and difficult to clean. However, until new machines are designed, little can be done about this problem. A great deal of research is needed on the manufacture of sanitary canning equipment.

Accomplishments of N.C.A.

The most significant accomplishment of the National Canners Association sanitation program probably has been its educational features. In the western program these have consisted of two types of course, each with a specific purpose, and for convenience of distinction they have come to be known as "conferences" and "training courses."

Of two-day duration, the conferences were designed to place before management and the operating personnel the advantages of sanitation, point out its significance, and present information which could be used in improving the sanitation of their canning plants.

Inasmuch as conferences were held near the plants, it was possible for large numbers of employees to attend and receive a sufficiently general background to become cognizant of the importance of sanitation. Fifteen conferences held in 1946 were attended by 986 people representing 279 canning plants. In the seven conferences held in 1947, there were in attendance 359 people representing 97 different canning plants. The results of such broad conference contacts were gratifying.

Visits were made to many of these plants during the operating season, and it was observed that while not all of the problems had been solved, there was evidence of a sanitation consciousness which was bearing fruit. It was determined by conferences in 1945 and 1946 that visual aid and free discussions served as the best means of expressing ideas and conveying information to an audience of such varied training and experience. For this reason, in the 1947 conferences, one quarter of the time was devoted to presenting movies and slides and one quarter to panel discussions on cleaning, waste disposal and other topics as selected by those who attended. The remaining time was utilized for lecture presentation.

The training courses were two weeks in length and were designed to train men selected for sanitation responsibilities and give them sufficient background to take the initiative in developing a plant sanitation program and in instigating new and improved methods. It was intended that these men be taught in considerable detail the different phases of sanitation. Therefore, authorities from various fields were engaged to present some of the material. The teaching roster of outside lecturers averaged 42 for the three courses held. Approximately ten percent of the time was devoted to visual aid material, and the remainder of the time was devoted to lectures, panel discussions and field trips. Field trips, for the purpose of demonstrating sanitation in action, were arranged for each course. The lectures and discussions were recorded for later distribution.

These courses and conferences have aroused great interest in sanitation wherever they were held. This was evident especially from the large attendance of supervisory personnel at a recent open forum sanitation conference held in San Francisco. Out of 100 present, there were three owners, eight managers, 13 superintendents, 27 foremen, and 44 sanitarians and technical men representing canneries in five western states and Alaska. This general interest in sanitation, along with a realization of the value of the program, has led to a free exchange of ideas between companies for the benefit of the whole industry and undoubtedly accounts, at least in part, for the industry-wide success of the program to date.

Another outstanding contribution of the National Canners Association to improved sanitation has been personal contact with individual canners and sanitarians for reviewing and discussing their specific problems. This service, along with surveys, has been most helpful.

The surveys made in the western area during the past year were of two types; namely, general surveys of all plant conditions, and surveys of clean-up operations, with special attention given to adequacy and efficiency of the methods used.

The Western Branch Laboratory's Sanitation Staff, in addition to these educational activities, has participated in various canners' meetings; conducted sanitation surveys in the western United States, Alaska, and Hawaii, furnishing confidential reports to the managers of each; investigated and informed canners concerning the aspects of water pollution in the disposal of cannery wastes; furnished information on specific problems in response to canners' requests; published a periodic sanitation news letter; and prepared a paper on cleaning for publication in *Food Industries*. Another contribution has been the compilation of references and listing of publications pertaining to sanitation.

This detailed description has been largely confined, as was mentioned earlier, to the activities of the Western Branch Laboratories of the National Canners Association. The programs of the two N.C.A. Laboratories have been parallel, especially in the emphasis given to education, but have differed in that the Washington Laboratory gave proportionately more emphasis to disposal of cannery waste. Both groups have the common objective of promoting the best sanitation possible in the canning industry, and the general outlines of the program just described are common to the two.

The Cannery Sanitation Program initiated in April of 1945 has been accepted warmly by the industry. It offers canners (1) the opportunity of obtaining an unbiased, detailed, confidential report on the sanitation of their plant and operations which can be used as a basis for a plant improvement program, (2) practical suggestions toward the solution of sanitation problems, (3) a source of information on sanitation developments applicable to canneries and (4) a method of stimulating plant personnel toward improvements in plant sanitation

practices. The availability of a direct service has been an asset to the individual canner.

The Future of Sanitation

Sanitation is only a relative term and, therefore, the canners' and sanitarians' viewpoints must not become static. It should be kept in mind that sanitation requirements are based on the education and demands of the consumer and these may result in new standards as time goes on. Thus, sanitation is a never-ending job. There always will be room for improvement.

This calls for continuous research and study and, while much has been done in the field of sanitation during the past three years, figuratively speaking, "we have merely wet our feet." The type of construction and methods of handling food used in some plants do not comply fully with present sanitation standards. Sanitation is a vital feature of canning operation, but sanitarians in some plants have been overloaded with other jobs and they have been unable to maintain the sanitary conditions they desire.

During 1948, the National Canners Association educational program on sanitation will be continued and will include the following service features: Instructing new sanitarians, developing visual aid material, disseminating new ideas, investigating by way of research new methods of sanitation control, and presenting conferences for a review of the many problems and new developments.

THE FIFTH YEAR OF THE NUTRITION PROGRAM

By E. J. Cameron, Director, Washington Research Laboratory, N.C.A.

From experience, I have found that any report on progress in the N.C.A.-CMI Nutrition Program should carry a preamble to summarize its background. This series of nutrition studies is now midway in its sixth year (our nutrition year begins June 1) and, although we have followed two basic lines of research, there have been several branchings which have led to areas seemingly remote from the original plan. Actually, all of the individual studies that have been made tie into one or the other of the two principal phases of the program.

Two Phases of Program

Briefly, Phase I investigations were applied to the determination of the principal nutrients that are to be found in foods after canning. About 40 non-formulated products were assayed for six vitamins, three minerals, fat, carbohydrate, and protein. Samples of each product were representative of the areas in which they were canned to an important extent, and the information that was gained presented a truly comprehensive picture of the nutrition factors which might be expected in a cross-section of these classes of canned foods.

Most of the Phase I results were obtained from testing fruit, vegetable, and fish samples collected in 1942 and 1943, and fish samples from the 1946 pack. Collateral to the Phase I investigations were studies of the effect of cooking on vitamin content as the food is prepared for the table, and the distribution of nutrients between solids and liquids.

Phase II of the program has centered on cannery studies to trace changes in nutrients at the various steps in preparation and processing. They have been referred to for convenience as "plant improvement" studies because their results should point the way to improvement in methods and equipment. In this group of studies, products have been followed step by step from the time they reach the cannery on through the final processing operation. Special tests have been carried further, into studies of storage effects under conditions of controlled temperature and in commercial warehouses. As a companion study, there has been a two-year temperature survey of 85 warehouses located in representative parts of the country, a report on which is now in preparation. Information thus acquired is basic in future planning toward improved nutrition through canned foods.

In his report one year ago (Supplement to the N.C.A. INFORMATION LETTER No. 1200, January 31, 1947), Dr. Esty stated that most of the work under the nutrition program has been done in research laboratories not connected with the canning industry, and he listed the collaborating nutrition groups. He also reviewed briefly the nature of the work each group had undertaken. Therefore, it is unnecessary for me to comment on the location of our research studies prior to 1947.

1947 Research Grants and Studies

During 1947, extended grants were made to Michigan State College and to the New York State Agricultural Experiment Station, Cornell University, for a continuation of Phase II studies on the effects of holding of products before and after blanching. At Michigan State, emphasis has been placed on the investigation of holding effects before blanching, as follows: Growing and handling of raw products; changes in vitamin content of vegetables during storage prior to canning; and changes of palatability of vegetables due to storage prior to canning. Reports of these studies for publication are in preparation.

At the New York State Agricultural Experiment Station, attention has focused on the chemical changes which occur on holding of peas, green beans, and lima beans after blanching with variation in times and temperatures. These studies have been unique in that they have included consideration of changes in the enzyme systems along with vitamin changes.

It is with regret that I announce that Pennsylvania State College has been unable to participate in the program set up for 1947. Outstanding from the outset of the program have been the investigations and reports of Dr. Guerrant and his co-workers, on blanching and storage effects and other important projects necessary to our research plan.

Amino Acid Studies

The nutritionist has given increasing attention in recent years to the role of the amino acids in human nutrition, especially those which are in the "essential" category. A few years ago when Dr. Rose, working with the support of Nutrition Foundation, reported the dramatic occurrences in animals and man resulting from the absence of these essential protein fractions, our Nutrition Committee gave serious consideration to support of protein studies on canned foods. At that time it was learned through consultation with authorities in the protein field that there was question about the adequacy of assay methods. However, there was felt to be considerable promise in the micro-biological methods then under investigation.

There is now reasonable assurance that assays by the microbiological methods are reliable, rapid and easy to perform, and with that assurance the Committee in 1947 voted to undertake Phase I amino acid studies in certain canned meat and fish products.

Following this decision, conferences were held with Dr. Elvehjem of the University of Wisconsin and Dr. Dunn of the University of California, Los Angeles. Both expressed interest in the problem, and detailed plans were made for the execution of the work, which is now active in both universities, supported by grants from our nutrition fund.

Products which have been selected for assay will be analyzed in the raw (frozen) and canned condition. It is of interest to note the products which have been selected for assay: Luncheon meat (or spiced ham), corned beef, whole boned ham, sardines (Pacific and Atlantic), tuna, salmon, mackerel (Pacific and Atlantic), and fish flakes.

This series of tests to be made in the two laboratories represents a unique arrangement because similar samples will be tested at both. It has

not yet been decided whether assays will be confined to the ten essential acids, or whether others of the 23 amino acids which make up the proteins will be considered. There is the limitation that only about 15 of them have been determined quantitatively through the use of microorganisms.

1947 Commercial Blanching Tests

In last year's report on the Nutrition Program, Dr. Esty announced that a cooperative study with equipment manufacturers was under consideration and that a meeting was planned for January 23, just following the 1947 Convention. He cited blanching equipment as the principal element of discussion, and said that redesigning might be necessary in order to make possible a greater retention of nutrients. The conference was held as scheduled, but adjourned without positive action.

At the May, 1947, meeting of the Executive Nutrition Committee Drs. Pilcher and Feaster submitted the following memorandum to the Special Committee on Equipment Improvement:

"The writers understand that as a result of the Atlantic City meeting on January 23, 1947, there has been no specific response to the invitation for cooperative study of the problem of canning equipment improvement issued at that meeting from those companies in attendance. This memorandum is written to suggest consideration by the Special Committee of two specific proposals:

I. PROPOSED 1947 STUDIES ON COMMERCIAL BLANCHERS

"It is generally agreed that enough data are at hand on the effect of commercial blanchers and blanching schedules on the retention of nutrients in specific products. No attempt has been made to date, however, to improve retention of such nutrients through alteration of existing blanching schedules. It, therefore, seems important that data be obtained as to how existing blancher operations might be improved. Such data should be helpful in future discussions with individual canners on desirable alterations in blanch schedules.

"Consequently, the following plan of procedure is suggested:

"A. That arrangements for work in their plants be made with pea canners in the three areas represented by the three Regional Committees. One canner each would be selected in the Eastern and Western areas, and two canners in the Central area. Companies selected should be N.C.A. members.

"B. The field work would be done by the laboratory staffs of the N.C.A. Washington and San Francisco Laboratories and the American and Continental Can Companies' Research Departments or Divisions, unless suitable arrangements with other agencies can be made. Such laboratories would be reimbursed for any direct labor and travel expense involved.

"C. Existing blancher practices for standard or extra standard peas in the plants selected would be evaluated for retention of ascorbic acid and thiamine. Appropriate samples for chemical analysis and for grading would also be obtained.

"D. Based on information obtained from the vitamin retention results from C, one or possibly two altered blanching schedules would be suggested to the canner for one hour's operation, in the course of which work similar to that outlined under C would be repeated and the hour's experimental production set aside.

"E. The canner should be reassured that any difference in product value resulting from failure to obtain the desired quality grade would be compensated.

"Consideration of this proposal, particularly by canner members, with special reference to its technical feasibility and possible cost, is respectfully requested. Further proposed experimental details can be supplied upon request.

II. POLICY ON CONTACTS

"The Special Committee is likewise requested to formulate a written policy for guidance of the Executive Committee and the Regional Committees with respect to the freedom of these committees in dealing with individual equipment manufacturers in the interest of developing a cooperative program for study of canning equipment improvements.

R. W. PILCHER
J. F. FEASTER"

These studies, to determine how existing blanching operations might be improved, and to provide information for cooperative investigation of blanching equipment, were undertaken in the 1947 season. The plan set forth in Dr. Pilcher's memorandum was followed substantially, but with two rather important deviations: (1) Work was done only in the Northwest and Midwest, and (2) only commercial blanchers were used in the Northwest experiments, while in the Midwest, tests were conducted with a small scale blancher which was operated in parallel with a commercial blancher.

Reports of the completed investigations will be made available to equipment manufacturers, and it is planned very soon to arrange for one or more conferences to reopen discussions which, it is hoped, will lead to realization of the cooperative plan which had to be abandoned in 1947.

The interest of our Committee in its consideration of the equipment problem must be apparent. Our plant improvement studies have shown where, and how, certain nutrient losses occur. Repeated testing has shown similar results. Some of this loss is preventable, and the next step should be to attempt to apply the prevention. We know that blanchers, and present means of blanching, are responsible for losses, and this equipment is a logical point for attack if we are to demonstrate how certain of the findings of the nutrition program are to be applied constructively. As an aside, the present day reel-type blancher is, in the opinion of many of us, the least sanitary of canning equipment, and an overhauling of it, in design or principle, might well benefit the objectives of our sanitation program as well as our efforts in nutrition.

Publicity on Nutrition

During the fifth-sixth year of the National Canners Association-Can Manufacturers Institute nutrition program, eight reports from collaborators were published, bringing the total published papers to 25. The new reports in the series "Nutritive Value of Canned Foods" are listed below:

XIV. "Effect of Commercial Canning Operations on the Ascorbic Acid, Thiamine, Riboflavin, and Niacin Contents of Vegetables," by Wagner, Strong, and Elvehjem, *IND. ENG. CHEM.*, August, 1947.

XV. "Effects of Blanching on the Retention of Ascorbic Acid, Thiamine, and Niacin in Vegetables," by Wagner, Strong and Elvehjem, *IND. ENG. CHEM.*, August, 1947.

XVIII. "Further Studies on Carotene, Ascorbic Acid, and Thiamine," by Hinman, Higgins, and Halliday, *J. AM. DIET. ASSOC.*, March 1947.

XXI. "Retention of Nutrients During Commercial Production of Various Canned Fruits and Vegetables," by Lamb, Pressley and Zuch, *FOOD RESEARCH*, July-Aug., 1947.

XXII. "Effect of Time and Temperature of Storage on the Vitamin Content of Certain Commercially Canned Fruits and Fruit Juices," by Moschette, *IND. ENG. CHEM.*, August, 1947.

XXIII. "Effect of Duration and Temperature of Blanch on Vitamin Retention by Certain Vegetables," by Guerrant, Varich, Fardig, Ellenberger, Stern, and Coonen, *IND. ENG. CHEM.*, August, 1947.

XXIV. "Effect of Duration and Temperature of Blanch on Proximate and Mineral Composition of Certain Vegetables," by Kramer and Smith, *IND. ENG. CHEM.*, August, 1947.

XXV. "Vitamin Content of Canned Fish Products, by Neiland, Strong and Elvehjem. *J. NUTRITION*, December, 1947.

In his report last year, Dr. Esty referred to the nutrition advertising of the Home Economics Division. Ten advertisements were prepared in 1946, the last three of which appeared in the first three months of 1947.

A new unit of advertisements, consisting of four pages of nutrition information based on the N.C.A.-CMI research, was prepared in 1947 in cooperation with the publication subcommittee of the Nutrition Committee. Three pages of advertisements appeared in 1947 and the fourth page in January, 1948. Seven professional magazines were used. Application was made to the Council on Foods and

Nutrition of the American Medical Association for its seal of acceptance for the vitamin and mineral advertisements. The seal was granted.

Originally, it was planned to publish this bulletin in 1947. As it required editorial work, it will be understood that there has been some difficulty in maintaining activity on the part of all collaborators. I am glad to report, however, that the bulletin is well advanced in preparation.

THE PROBLEM OF DETERIORATION IN FLAVOR OF CANNED ORANGE JUICE

By R. E. Henry and L. E. Clifcorn, Research Dept., Continental Can Company, Inc.

The deterioration of flavor during storage of canned orange juice always has been a problem with the citrus canning industry. This has been especially emphasized by the number of investigations reported throughout the years and the number of patents issued with the particular objective of providing a better-tasting canned orange juice for the consumer.

Although this laboratory has made worthy contributions toward its solution, it has been largely through the combined efforts of the entire citrus canning industry that canning methods showing a definite improvement in the flavor of freshly-canned orange juice gradually have been developed. As a result, juice freshly canned by the best methods approaches very closely the quality of the raw juice. The flavor, however, gradually deteriorates depending upon the time and temperature conditions of storage. The chemical mechanisms involved in this deterioration are unknown and have received a great deal of our attention during recent years.

Indications from Previous Investigations

The work of Nolte and von Loesecke (1940) is one of the earliest which is related directly to the problem of off-flavor development. They found that the ether extract of fresh orange juice had a bland taste and a fragrant odor, while the extract of aged canned juice had an unpleasant, rancid taste and a stale tallowy odor. A number of tests performed on these materials showed a strong indication of rancidity development which apparently was the result of oxidation accompanied by hydrolysis. They concluded that although the oxidative changes in the fatty material of aged canned juice may not be entirely responsible for its deterioration, they certainly play an important role. Although the accumulated data do not indicate the manner by which the oxidative changes were brought about, these authors thought they might result from the oxygen left in the headspace of the container, or through enzyme activity, or that the fatty material in the juice might take up oxygen in loosely bound forms, which Holm, Greenbank, and Deysher (1927) called "moloxides." These are alleged to be responsible for the oxidation of fats even under high vacuum.

That the development of off-flavors in canned juice is related to the volatile oil content also has been rather strongly indicated by the work of Boyd and Peterson (1945) of this laboratory. In their work they found that objectionable off-flavors developed in juice with the oil content as low as 0.01 percent, while a number of experimental packs in which the oil content was below 0.007 percent (one as low as 0.001 percent) did not develop the off-flavors as did the higher oil content juice, even after 18 months' storage at room temperature. From this it seems apparent that the higher the volatile oil content, the more rapid the development of off-flavors.

The role of dissolved oxygen and oxygen in the container headspace in the deterioration of orange juice has not been well defined, although the current practice in the industry is toward oxygen elimination. According to the work of Boyd and Peterson (1945), orange juice packed in plain cans without coming in contact with air during the complete juicing and canning operations in general retained its flavor better than commercially canned juice. In other packs where the juice was extracted in air, deaerated immediately, flash sterilized, cooled, and canned under aseptic conditions in an atmosphere of nitrogen, the flavor was very close to that handled entirely under nitrogen.

On the other hand, in packs made under normal canning conditions where no attempt was made to remove the dissolved oxygen and headspace oxygen, the juice deteriorated more rapidly during storage. However, the incorporation of antioxidants supposedly to eliminate the influence of oxygen seemed to have no effect on the time required for the development of off-flavors. This substantiated the work of Nolte, Pulley and von Loesecke (1942), who, although believing considerable oxidation took place in the can, found no benefit could be obtained by the addition of several common antioxidants. Riester et al (1945) sought to determine the influence of container headspace oxygen on flavor deterioration by comparing orange juices sealed in plain cans with and without headspace oxygen. The results obtained from a flavor-tasting panel showed that no benefit was obtained by substantially complete elimination of the headspace oxygen. In addition, as other investigators have found, no flavor advantage was obtained by the addition of antioxidants. The findings, although not conclusive, indicate that dissolved oxygen and container headspace oxygen, at least in orange juice packed in plain cans, may be insignificant factors in the development of off-flavors.

After due consideration of the published information and that available in this laboratory on the problem of off-flavor development, the following points seemed apparent:

1. There has been no correlation of physical or chemical tests with the development of off-flavors.
2. Off-flavors appear to be quite definitely related to the volatile oil content, or petroleum ether-soluble material.
3. Little or nothing is known of the constituents responsible for the off-flavor.
4. It is not known definitely whether the type of reaction responsible for the off-flavor is oxidative, hydrolytic, a combination of both, or an interreaction of various constituents.
5. The relation between the so-called cooked flavors and the development of off-flavors has not yet been established.

New Work Undertaken

The complexity of the problem of improving the flavor of canned orange juice has made it necessary that exploratory work be done in order to determine the proper avenues of approach upon which considerable emphasis could be placed.

Polarographic Oxygen Studies

Inasmuch as several references have been made to the deleterious effect of dissolved oxygen as well as headspace oxygen upon the flavor of canned orange juice, it was decided to study briefly the rate of loss of dissolved oxygen in orange juice sealed in plain cans.

The details of the polarographic method for the determination of dissolved oxygen as used in this laboratory for the past two years recently have been described by Lindquist (1947). Since it is difficult to incorporate a reasonable amount of oxygen in juice at 190° F. under laboratory conditions, the freshly expressed juice was first heated to 190° F. to inactivate the enzymes, cooled to room temperature, aerated and sealed in plain cans at room temperature with chloroform added as a preservative. The juice was then analyzed at intervals providing the results shown in Table I.

TABLE I

Rate of Depletion of Oxygen from Orange Juice Packed in Plain Cans

Aerated juice	Percent saturation with O_2
Before sealing	49.0
Immediately after sealing	49.0
1 hour after sealing	24.0
2 hours after sealing	5.5

The ascorbic acid content did not change during this period of analysis, showing that the oxygen was not being taken up by this substance but was being eliminated by some other means possibly involving the tin surface. The question of the relative amounts of oxygen being taken up by the tin surface and the orange juice constituents is under investigation.

To further investigate the loss of oxygen, aerated, pasteurized orange juice was placed in 250 ml. glass cylinders, covered with a protective layer of mineral oil and samples were removed periodically in order to determine polarographically the rate of oxygen up-take. The oxygen disappeared at a rate approximately six times slower than was the case with the orange juice packed in plain cans. The accompanying loss of ascorbic acid accounted for only 40 percent of the oxygen absorbed. This same relationship appeared to exist whether screened pasteurized or clarified pasteurized juice (substantially free from oil) was used. These findings serve to indicate that some material other than ascorbic acid also is absorbing oxygen which may or may not be related to the off-flavor development.

Since our observations substantiated those of Nolte and von Loesecke (1940), in that the off-flavors developed in the ether-extractable fraction of canned orange juice, it seemed desirable to compare the absorption spectra of the ether extracts of fresh orange juice and aged canned juice. From the absorption spectra curves obtained using a Beckman spectrophotometer, the light-absorbing characteristics of the two samples are, in general, quite similar except for a slight inflection at 324 millimicrons in the curve for the fresh juice extract. Since the inflection at 324 millimicrons occurred in the fresh juice extract but not in the off-flavored canned juice, there was a possibility of its being related to a substance which might undergo a change upon aging.

Chromatographic and Spectrophotometric Absorption Studies

Consequently, an attempt was made to isolate a fraction containing this material by chromatographic adsorption. A petroleum ether extract was made of fresh orange juice and chromatographed on a MgO-Hyflo Supercel column, petroleum ether being used because of its excellent chromatographing characteristics. Using the adsorption bands of the pigments as a guide, various fractions were taken from the column, the odor noted and absorption spectra measurements made, using di-ethyl ether as the solvent after evaporation of the petroleum ether. The absorption curves showed no inflection at 324 millimicrons nor were there any absorption maxima in the odor-containing fractions. It is apparent from these results that the material responsible for this small response in the ultra-violet spectral region either was lost during the fractionation or occurred in such small quantities that an elaborate means of fractionation would be required to isolate a measurable quantity. The latter is more likely to be true inasmuch as the original absorption curve showed a small inflection rather than a maximum.

Absorption spectra also were determined in the spectral range of 200-700 millimicrons with steam distillates from aged canned juice and, for comparison, on a freshly extracted juice. Di-ethyl ether was used as a solvent, and both samples showed a broad absorption band between the wavelengths of 300 to 400 millimicrons with no sharp inflections in evidence. Since these distillates contained almost entirely the flavor and odor of the original juice, this, together with the results from the absorption spectra measurements, provides persuasive evidence that little information is to be obtained by this approach as to the character of the constituents responsible for the off-flavor.

Steam and Vacuum Distillation Studies

Inasmuch as a considerable amount of heat is involved in steam distillation which might cause a change in the constituents, an attempt was made to vacuum-distill the off-flavored constituents of aged canned juice at room temperature and capture the volatiles in a dry ice-methanol trap. After six hours distillation at reduced pressure, the residual material in the distilling flask had lost all of its odor and practically all of its original bitter flavor. The dry ice-trapped volatiles upon thawing had a very strong off-odor and off-flavor. The distillate was then treated with 2, 4,-dinitrophenylhydrazine to precipitate those compounds having active carbonyl groups (ketones, and aldehydes). Although a slight precipitate formed, the off-odor was not materially altered. Canned juice from the same pack was also steam-distilled with identical results; i.e., steam distillation removed practically all of the off-flavored constituents and the odor of the distillate was not altered by the addition of 2, 4,-dinitrophenylhydrazine.

In further analysis of the steam distillates from which the aldehydes and ketones had been removed with 2, 4,-dinitrophenylhydrazine, the off-odor was completely destroyed by both $KMnO_4$ and bromine water. The resulting decolorization of these reagents gave a positive indication of unsaturation in the off-flavored constituents. In addition, these substances were found to be steam-distillable from an alkaline medium, thus eliminating any volatile organic acids as a possible source of off-flavor.

From these results it seems reasonable to assume that the offending material or materials are unsaturated hydrocarbons or alcohols possibly related to *d*-limonene which makes up approximately 90 percent of the volatile orange oil.

Cooked Flavor vs. Aged Flavor

In considering the deterioration of flavor in canned orange juice, much emphasis has been placed on the effect of heat. Holding the juice at high temperatures for relatively long periods of time prior to and after sealing are known to cause a rapid deterioration of flavor. In the industry it is generally accepted that cooked flavors which accompany heating gradually disappear from juice packed in plain cans during the first few weeks of storage. It also has been suggested that cooked flavors are related directly to the development of off-flavors; i.e., the materials responsible for the cooked flavors change gradually during storage to give the typical terpene-like flavor of aged canned juice. Others, however, have taken a more conservative viewpoint, offering the opinion that strong-cooked flavors are a definite indication of juice of inferior quality, which will deteriorate rapidly during storage.

In order to obtain some additional information about the effect of heat, the development of cooked flavors in fresh juice was first investigated in the presence and absence of dissolved oxygen. For this purpose 50 ml. of aerated fresh juice was placed in each of three test tubes and immersed in a boiling water bath, which gave the results in Table II.

TABLE II

Effect of Heating on Flavor

Heating time	Flavor characteristics
5 min.	Fresh orange juice flavor—little change
15 min.	Pronounced cooked flavor
30 min.	Very pronounced cooked flavor

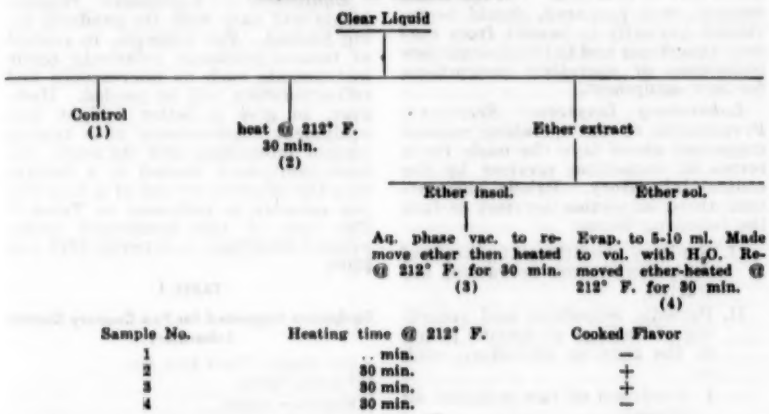
This experiment was then repeated with juice which had been deaerated by bubbling nitrogen through it until the polarograph indicated the absence of oxygen. The results were identical with those from the aerated juice, showing that the presence of oxygen had little influence upon the development of cooked flavors.

To further characterize the constituents responsible for the cooked flavors, fresh orange juice was clarified by centrifuging, the clear liquid divided and treated according to Diagram I.

These results indicate quite strongly that the constituents responsible for the development of cooked flavors are associated with the water soluble phase, while the aged flavor, as had been shown previously, is related to the ether soluble phase.

DIAGRAM I

Experiments on Cooked Flavor


Clear Liquid
Control (1)
heat @ 212° F. 30 min. (2)
Ether extract
Ether insol.
Ether sol.
Aq. phase vac. to remove ether then heated @ 212° F. for 30 min. (3)
Evap. to 5-10 ml. Made to vol. with H2O. Removed ether-heated @ 212° F. for 30 min. (4)

Sample No.	Heating time @ 212° F.	Cooked Flavor
1	.. min.	−
2	30 min.	+
3	30 min.	+
4	30 min.	−

In another experiment a number of 202 x 214 cans were packed with juice, a portion of which had been heated to 190° F. for three minutes while the other portion had been heated to boiling for 30 minutes prior to filling and sealing. These cans were placed in storage at 98° F. and examined after seven and 29 days, producing the results shown in Table III.

TABLE III

Effect of Storage on Flavor

Treatment	Days incubation at 98°F.	Flavor * Fresh	Cooked	Aged
190°F. for 3 min.	0	†††	...	...
190°F. for 3 min.	7	...	...	†††
190°F. for 3 min.	29	...	...	††††
212°F. for 30 min.	0	...	††	†
212°F. for 30 min.	7	...	†	††
212°F. for 30 min.	29	...	...	††††

* † Mild, †† Marked, ††† Strong, †††† Very Strong.

From this work it appears that the reaction producing the cooked flavor is not related to the development of the typical aged flavor of canned juice. Although they are unrelated, the two reactions may proceed simultaneously but independent of one another and at a rate dependent upon the temperature alone.

Summary

A number of exploratory laboratory experiments were conducted in attempting to obtain more information concerning the constituents responsible for the off-flavor development in canned orange juice. During the course of this work, it was shown that dissolved oxygen disappeared quite rapidly from juice in a plain can, approximately six times as fast as in glass. Although there was a loss of ascorbic acid in the latter instance, it did not account for all oxygen loss, indicating the presence of other oxygen-absorbing materials.

Although there was considerable evidence obtained in support of the volatile oil fraction as the major contributor to off-flavor development, little information was obtained regarding the identity of the responsible constituents except that they were unsaturated, easily-oxidized hydrocarbons or alcohols. It appeared, however, that *d*-limonene was associated with the flavor deterioration.

It also was shown that the reactions responsible for cooked flavors were unrelated to those associated with the aged flavor, but both may proceed simultaneously at a rate dependent upon temperature.

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MINIMUM REQUIREMENTS FOR A SMALL PRODUCTION AND QUALITY CONTROL LABORATORY

By O. R. Alexander and O. G. Braun, American Can Co.

The value to the canner of a complete and efficiently operated production and quality control laboratory is generally well recognized. In an address before this conference last year, J. E. Hall gave an excellent presentation of the organization and objectives of a quality control program.[1] Of particular value was his rationalization of the function of such a program; namely, to obtain and provide information which permits each employee to exert the intelligent effort necessary for the production of a superior product.

It is generally recognized, likewise, that the heart of any production and quality control program is a laboratory functioning on a full-time basis to prevent economic losses through spoilage, to maintain or to improve quality grade, and to assure complete compliance with mandatory legal standards or regulations. Therefore, the problem confronting the canner who may desire to institute production and quality control reduces itself to a consideration of whether or not the initial cost and annual operating expense of such a laboratory are economically feasible under his particular operating conditions. This is particularly true of the small or medium-sized manufacturer operating only on one or a few seasonal products.

In some instances, where considerable losses have been encountered in the past which might have been prevented by technical services, the canner has a more valid or practical basis for decision. Likewise, where products such as tomato products, subject to certain regulations capable of control only by laboratory techniques are being packed, the decision to establish such services may be more readily reached.

Intermediate between these two situations, however, is that of the canner who may recognize the ultimate value of a production and control laboratory but who also must establish to his own satisfaction that the necessary initial cost and continued operating expense, under his circumstances, will definitely pay off. Here the decision is more difficult and the basis of judgment, as aptly quoted by Lueck,[2] must be a consideration of the cost of founding such a unit as compared to the possible cost over the years of not founding it.

Canners who find themselves in this position have sought more specific information regarding modern production and control laboratories than has thus far been available. In particular, they seek to learn the proper activities or functions of such a labora-

tory, the relations of the laboratory to the plant manufacturing procedure and personnel, the physical and personnel requirements, and the equipment which would be needed. Obviously, no set pattern can be drawn up and applied with equal success to varying sets of conditions. However, it is possible to establish within reasonable limits the types of operations and the minimum requirements for a small production and control laboratory. It is the purpose of this paper to list such requirements in the hope that this information may prove of service. The scope of the paper does not permit discussion of the requirements of the new products or development laboratory which usually is a logical outgrowth of the control laboratory and a further impelling reason for its establishment. Instead, this discussion will be limited to listing the specific details of what might be considered the start of a laboratory for a moderate-sized packer of seasonal products.

General Operation

Briefly stated, the operations of a production and quality control laboratory may be divided into three areas: (1) Raw material selection and segregation; (2) control of canning procedures and equipment and (3) examination and grading of processed material. The operations of a control laboratory within these three areas are outlined in the following sections.

Raw Material Selection and Segregation—One useful function of the control laboratory can be to provide the field man with the results of available objective tests of the quality of maturity of the produce in order that the most satisfactory harvesting schedule can be worked out. It is beyond the scope and purpose of this paper to discuss these tests; however, they have been described in a recent publication.[3] Segregation of raw material into proper quality grades becomes increasingly expensive and difficult the further along in the canning procedure the attempt at segregation is made. Consequently, segregation is most easily accomplished at or before the time of harvest.

As later described, the quality control laboratory may also concern itself with the condition of the other raw materials used in the preparation of the finished product.

Operating Manual on Procedure and Equipment—For most effective operation of a control laboratory, canners will find it desirable to prepare a manual of operating instructions for key production personnel outlining the details of canning procedures which are to be followed. The preparation of such a manual is primarily the responsibility of management. However, the control laboratory may be of material assistance in its preparation. There are a number of agencies where information regarding proper processing techniques, blanching schedules and other details of canning procedures may be obtained. The operating manual, once prepared, should be reviewed annually to benefit from current experience and to incorporate new techniques or operating instructions for new equipment.

Laboratory Inspection Services—Preparation of the operating manual suggested above lays the basis for a series of inspection services by the control laboratory. Briefly summarized, these inspection services include the following items:

I. Sanitary conditions of plant and equipment before operations are started.

II. Periodic inspection and recording of findings at specific points in the canning procedure, such as:

1. Condition of raw material on receipt.
2. Efficiency of cleansing operations.
3. Accumulations of refuse which might harbor food spoilage organisms.
4. Efficacy of plant food handling operations, such as trimming, sorting, etc.
5. Compliance with all provisions of the operating manual with respect to the details of canning procedure.

Examination and Grading of Processed Material—Two distinct and separate phases of this portion of the quality control program may be recognized; namely, the routine incubation of line samples to control spoilage, and the examination and grading of representative samples. These possible applications of the control laboratory are explained later.

Laboratory Requirements

Having broadly outlined the fields of activity of the production and quality control laboratory, the requirements of the laboratory itself might be considered next.

Physical Requirements — A well-lighted room, apart from yet within easy access to the canning floor, should be set aside for the laboratory. The size of the laboratory or the arrangement of the facilities is not at all critical. However, a minimum of 20 linear feet of bench space is highly desirable. The room should be supplied with electric power and running water at a sink similar to the familiar kitchen model. Ample storage facilities should be provided for holding retainer samples for possible future reference and provision also made for the collection and disposal of refuse.

The cost of the laboratory itself may vary over wide limits depending upon the size, the materials used in its construction, the amount and cost of labor required, and other factors. Consequently, no estimate of the probable cost of providing adequate physical space has been attempted here.

Equipment — Equipment requirements will vary with the products being packed. For example, in control of tomato products, relatively costly instruments such as microscopes and refractometers will be needed. However, to give a better insight into equipment requirements of a typical control laboratory and its costs, the basic equipment needed in a laboratory for effective control of a four-line pea cannery is indicated in Table I. The cost of this equipment under present conditions is between $275 and $300.

TABLE I

Equipment Suggested for Pea Cannery Control Laboratory

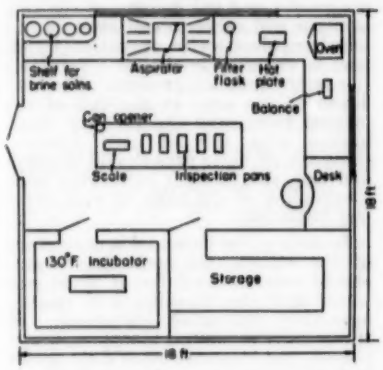
1 Can Opener, Heavy Duty type
1 Vacuum Gauge
1 Headspace Gauge
1 Scale with capacity of 10 lb. and accurate to 1/10 oz.
1 Set of weights
6 white enamel inspection trays, approximately 7½ x 12 x 2
1 Set of screens for size grading
1 Set 8" and 12" drained weight screens and pans
6 400 cc. beakers
1 small household sieve
4 Five gallon carboys for standard salt solution stocks
1 Hydrometer calibrated in per cent salt
1 Gravity cylinder or hydrometer jar
2 Pocket thermometers
1 Brom-cresol purple pH indicator in dropping bottle
1 Chlorine testing kit

The following items are needed for determination of alcohol insoluble solids:

1 Food chopper
1 Balance sensitive to 0.01 g. (torsion balance); capacity 500 g.
1 Set of metric weights
6 600 cc. beakers with cover glasses
1 Electric hot plate
1 Buchner funnel
Filter paper
1 Filter flask
6 Aluminum moisture dishes
1 Air drying oven
1 Aspirator
1 Graduated cylinder, 500 ml.

A suitable incubator having a capacity of six cases per line also should be provided. This unit may be constructed easily from an insulated wall board, using electric strip heaters as a source of heat and a simple thermostat as a control. Depending upon the size of the unit required, some form of air circulation to minimize temperature gradients should be provided, and small electric blowers are available for this purpose. The cost of this incubator, including labor and materials, is estimated at $200. In Figure I is shown one suggested arrangement and distribution of equipment for a control laboratory serving a pea canning plant.

FIGURE I



Personnel—Ideally, the quality control laboratory operations should be in charge of an individual who by education or experience is familiar with canning operations and who has sufficient technical skill to apply the tools necessary to gauge the various steps in the canning procedure. The experienced, college-trained food technologist, of course, is best suited for this type of work, and many such men are to be found in charge of the quality control programs in canning plants. In certain instances, some of these individuals eventually have taken over greater responsibilities in the production department or management of the company. Unfortunately, the available number of such qualified individuals is very limited and their current salary expectations are quite high. Likewise, it is seldom practical for the canner of seasonal products to employ such help. Where operations are on a yearly basis, employment of such an individual is more feasible, particularly if there is any possibility that the production and control laboratory would be expanded so as to include new product development work.

It is possible, however, to establish a valuable control program without formally-trained personnel. One practice which has been followed successfully is to select some member of the concern who is familiar with the entire plant operation and to train this individual specifically for the work he is to undertake. In such training, the laboratories of suppliers or other agencies associated with the canning industry are usually glad to cooperate. Selection of the individual is of great importance in instances of this type. As educational background, a high school education which possibly included science courses, is preferable but not mandatory. Perhaps the most important considerations are the alertness of the individual, his ability both to profit by experience and to recognize deviations from normal, the probable permanency of his employment, and, in the case of the smaller packer, his versatility or his ability to adapt himself to the work and problems of the organization in the off-season months.

If the situation makes temporary help during the season the most practical means of staffing the laboratory, some canners regularly recruit their necessary technical help from among the technical students at nearby colleges. Either men or women may be thus employed and the arrangement usually is very satisfactory for students majoring in foods, food chemistry or food technology because of the opportunity for acquiring practical experience in food preservation which the temporary employment provides. Similar arrangements also have been made with high school or college science teachers who are available during the vacation period. Such services usually should command salaries equivalent to or somewhat in excess of the rates paid for the more important or critical production jobs.

The number of persons required for effective operation of the production and quality control laboratory is variable and much dependent on the particular plant or plants involved. The amount of help required will be determined in general, by the demands which will be made on the time of the technologist in charge. As a general guiding principle, this technologist should be given sufficient assistance by one or more helpers who would relieve him of the more routine duties such as securing samples, keeping of records and the simpler examinations, so that he may devote most of his time to the more critical plant and product inspections. These helpers may be compensated within the range of rates paid for factory labor.

System of Records—The importance of preparing and keeping complete and accurate laboratory records and reports cannot be overemphasized. Printed check lists and forms designed to accommodate the required data are of considerable value and convenience and are relatively inexpensive. Figures II and III indicate forms which have been found useful in control of a pea cannery. These forms are preferably prepared in duplicate, one copy being retained in the laboratory files and the other submitted immediately upon completion to the management.

System for Reporting—No matter how well arranged, equipped and staffed a production and quality control laboratory may be, it will fall short of its purpose unless there is some orderly system for reporting its findings, particularly with respect to deviations from normal practice which may have been detected. It is important, therefore, that some system of reporting agreed upon in advance by all concerned, be set up which will lead to prompt correction of undesirable or hazardous practices or situations.

FIGURE II

Quality Control Laboratory Plant Inspection Report

Date..... Time.....

No. Boxes Peas on Hand
Condition of Peas on Hand
Condition of Wash Water
Condition of Washed Peas
Condition of Peas at end of picking tables
Temperature of flume water

	Line 1	*Line 2*	*Line 3*	*Line 4*
Tenderometer reading of peas being run				
Blanch—time (min.)				
temp. (° F.)				
Temperature of peas in grader				
Density of brine in grader (° Sal)				
Can Size				
Avg. fill-in weight (oz.)				
Closing Temperature				
Closing machine count				
Closing machine code				
Seam Examination Report (attached)				
No. filled crates to be processed				
Processing data (if recording instruments are not used)				
Temperature of cooled cans				
Chlorine conc. of cooling water				
Codes of samples taken for inspection				

Report by.....

FIGURE III

Quality Control Laboratory Product Inspection Report

Date.....

	Line 1	*Line 2*	*Line 3*	*Line 4*
Can Code				
Can Size				
Time of Sampling				
Vacuum (inches)				
Headspace (32nds)				
Temperature				
Gross Wt. (oz.)				
Tare Wt. (oz.)				
Net Wt. (oz.)				
F & D Standard Fill Test				
Drained Wt. (oz.)				
Size Distribution				
Salt Brine Flotation Score				
Alcohol Insoluble Solids (per cent)				
Color				
Defects				
No. discolored peas				
Extraneous material (designate)				
Wt. broken peas				
No. splits				
Flavor				
Grade				

Report by.....

Practical Application

Thus far only the broad fields of operation and the basic requirements for a typical production and quality control laboratory have been considered. Therefore, it appears desirable to describe more specifically how such a unit would operate under a specified set of circumstances. It should be emphasized that, knowing the products or combinations of products to be manufactured, the exact functions of the control laboratory may be readily outlined. For the purpose of exposition, the specific functions of a control laboratory serving a four-line pea cannery might be considered.

RAW MATERIAL SELECTION AND SEGREGATION

(1) *Raw Produce Testing*—As previously indicated, cooperation between the field man and the control laboratory at or before the time of harvesting is the preferred system of segregating raw material in order to produce the desired quality grade. Where this is not feasible, a check on the material as received in the plant can be made by sampling the raw stock at the canning plant and testing the samples in order to segregate the material into the various lots.

Various methods have been developed for effecting this initial quality segregation. With respect to peas, the most common of these are the tenderometer readings, texturemeter readings, salt brine flotation and size grading. However, with any product considerable care must be exercised by the control laboratory in the selection of an adequate sample for any one of these objective tests.

In regard to peas, the mechanics of the vining operation may in itself effect some segregation and a considerable variation in texture can be observed from one end of the viner to another. Peas normally are delivered to the plant in lug boxes directly from the viner stations, and unless proper sampling methods are employed, a representative sample may not be measured. The best place to sample a load of peas is at the vining station and the laboratory should arrange with the operator of the viner for the removal of some definite quantity—one pint cup, for example—from each filled lug box. These samples should be composited in a distinctively marked lug box and accompany each load to the canning plant. The sample lug box then contains a uniform portion of the contents of each of the lug boxes comprising the load and on arrival the technologist can remove the marked lug box, mix the contents thoroughly and withdraw a fairly representative sample for laboratory analysis.

In the laboratory, a sufficient number of analyses should be made to obtain a satisfactory average value, and this value, of course, should be made a part of the receiving record as well as a part of the production records. Based on the results of these objective tests, the load of peas may be diverted into one of the various grade lots being run.

It is perhaps unnecessary to point out that premium payments for quality produce, a practice followed by many packers, can be administered most satisfactorily by this system of objective tests made on the raw stock as received.

(2) *Other Materials*—While it usually is impractical for the small plant laboratory to be equipped or staffed to determine the quality of the water, sugar, salt or spices used, the control laboratory still can perform a valuable function by ascertaining that any materials purchased are bought under adequate, rigid specifications from reliable suppliers or that suitable samples are submitted to competent outside laboratories for analysis.

CONTROL OF CANNING PROCEDURE AND EQUIPMENT

(1) *Initial Inspection*—Before the start of the day's operations, the technologist in charge of the control laboratory should check the sanitary condition of the various pieces of equipment in the canning line. Any irregularities in the clean-up job should be reported immediately through established channels so steps can be taken to rectify the condition before operations are begun.

(2) *Control of Operations*—At the beginning of the pack and thereafter at two-hour intervals, the various steps in the canning procedure should be checked by the technologist in accordance with some plan similar to that presented in Figure II. The use of an inspection record, such as that illustrated, will go far toward insuring that a systematic survey is being made. Thorough observations would include an inspection of the quantity and condition of raw material on the receiving platform, inspection of the cleansing operations, detection of any accumulations of materials which might harbor food spoilage organisms, observations on the efficiency of sorting and trimming operations in removing defective units and those obviously unsuited for use, a check on the residual hardness of the water, if softening operations are used, the time and temperature of the blanching operation, the can closing temperature, fill-in weight or weights, top seam condition, retort operation, temperature after cooling, and the determination of residual chlorine when chlorination is being practiced.

Observation of the quantity of raw peas on hand to be processed will indicate any undesirable overloading of the plant with resultant excessive holding periods. Inspection of the raw peas being delivered and on the receiving platform should reveal the presence of peas carrying excessive amounts of weeds indicating faulty operation and adjustment of viners. Prolonged holding of the raw product may be detected by noting any temperature rise in accumulated lug boxes.

Careful attention next should be given by the technologist to the efficiency of the cleansing operations, both the preliminary dry cleaners as well as the washers. The operation of the size graders should be particularly observed in order to determine whether overloading, flooding, or mixing subsequent to size grading interferes with the efficiency of their operation.

Noting and recording the temperature of the peas going into the quality grader and the density of the salt solution will serve to call attention to any irregularities in operation which may be reflected in similar irregularities in the finished product. The condition of the peas at the end of the picking belts, and the freedom from broken peas, bits of pods, thistles, skins and off-color peas should be noted and any abnormality correlated with overloading of the belts or with careless inspection.

In noting the time and temperature of the blanch, the technologist also should note the condition of the blanch water and the washing and cooling operations following blanching. In the event that tubular blanching is employed, the inspector should recognize and report any condition conducive to the build-up of spoilage organisms in the recirculated blanch water. Fluming and pumping operations may become the focal points for growth of excessive numbers of spoilage organisms should the temperature of the water be allowed to rise.

Examination of top seam formation merits special attention. Adjustment of the can closing machine and maintenance of good seams are the responsibility of the closing machine operator who in the course of his duties should make frequent periodic examinations of the quality of the seams being formed. In order to avoid duplication of effort and to assign responsibility more definitely, some packers have found it advantageous not to include the actual stripping and examination of can seams in the functions of the quality control laboratory, the laboratory being responsible only for obtaining and recording the results of these seam examinations made by the operator.

Process Control Important

The proper operation of retorts is one of the most critical steps in the entire canning procedure since the effectiveness of the process may be materially reduced if the operation of the retorts is at fault. The quality control inspection should note any deviations from the accepted processing schedule, including the venting, time and temperature; records of recording thermometers should be collected where this equipment is employed; likewise, where they are used, process indicating tags or inks should be collected and filed. It also should be a responsibility of the quality control laboratory either to make a pre-season check on the calibration of process indicating thermometers and pressure gauges or to have this done by some reliable instrument manufacturer or repair service.

Cooling of the processed product is likewise an important factor to be controlled. The temperature of cooled containers at the end of the cooling

cycle should be determined and recorded and the exterior appearance of the containers inspected for evidence of excessive straining during the cooling process. In this connection, the quality control laboratory should also determine the concentration of residual chlorine in the cooling water where this practice is being followed.

A record of the closing machine count will be found of value in an analysis of the production records. In addition, the code markings should be checked carefully in order to make sure that the codes being embossed agree in all respects with the coding system employed. Observation of the number of filled containers waiting to be processed will focus attention on excessive holding periods at this point which should be eliminated.

The Warehouse—The plant inspection also should include periodic inspection of the warehouse. Evidences of spoilage should be looked for and the incidence of any rusty containers noted. A record of the warehouse storage temperatures, on occasion, subsequently has proved useful. The technologist also should be on the alert for any indications of can damage due to rough handling, to maladjusted runways or to damage in unscramblers and casing machines. This subject has been well covered in a recent paper by Smith.[4]

EXAMINATION AND GRADING OF PROCESSED MATERIAL

(1) *Incubation Procedure* — While complete bacteriological control of the canning operation would, of course, be ideal, daily sample incubation should be the minimum employed by the small control laboratory to check on the sanitary condition of the finished product. Incubation programs are of further value in determining as quickly as possible any potential spoilage hazards in the canned samples. Procedures for incubation studies in canning plants have been outlined by Thompson,[5] Cameron,[6] and Pearce [7] to which reference can be made. Minimum procedures would include the incubation of 12 samples from each canning line to be taken from the first crate of cans processed at the start of each day's operation. These samples should be stored at 130°F. and observed daily by the technologist for the incidence of swells. At the expiration of four days' incubation, one-half of the samples may be cut and examined for flat sour spoilage and at the end of seven days, the remaining flat cans should be opened and examined.

(2) *Examination of Line Samples*—In addition to determining compliance of the canning procedure with operating instructions, the control laboratory also should undertake examination and grading of line samples to check the finished product against the desired specifications set up by the management.

Representative line samplings for laboratory examination may be made during the plant inspection. While practice is variable, a minimum of two cans taken every two hours from every line, or two cans for every lot change should be secured, whichever is more frequent. One can suitably coded and identified should be retained for any subsequent examination required and the other inspected immediately.

The examinations to be made on line samples will vary to some extent with the plant involved. However, the minimum food inspection data to be obtained and recorded by the technologist should include net weight, vacuum, headspace, general observations for size distribution, uniformity of color, defects, extraneous material, flavor, and compliance with any other specification under which the canner is operating. The inspection report form shown as Figure III, lists typical measurements and observations which might be made. These are largely self-explanatory and need not be discussed further.

Conclusion

The organization, activities and responsibilities of a quality control program have been discussed, particularly as they apply to the operation of a moderate sized pea cannery. The specific details of any such program, however, may be modified to meet the requirements and facilities of any particular factory. It will be recognized that in the small plant many of the activities listed are now commonly performed by the operating management or supervisory personnel, and thus the employment of a production and quality control laboratory should relieve management of the necessity of checking details of procedure and production, allowing more time for broader duties leading to more efficient operation of the plant.

In addition, the quality control laboratory will function to minimize losses from spoilage of the product and serious conflict with established specifications. In the long run, additional benefits will be derived as the result of channeling higher percentages of the total production into the more profitable quality grades and the creation of an increased consumer demand for the uniform product being produced. The fact that some of the highly developed quality control systems now in effect have been inaugurated after economic losses had been experienced, points to the potential value of this service.

An attempt has been made to present definite information which, it is hoped, will facilitate decisions in the case of packers investigating the advisability of establishing production and quality control laboratories.

Acknowledgment

The authors wish to express their gratitude to the canners and their quality control supervisors who freely offered the benefit of their experiences in operating quality control programs and to our associates in the Research Division of the American Can Company who assisted in the preparation of this paper.

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CALCIUM TREATMENT OF CANNED FRUITS, VEGETABLES

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The two years which have passed since the end of the war have brought about a revived interest in quality production. This fact is noticeable in the market trends in various fruit and vegetables produced for the manufacture of canned foods, and also in the increasing desire to improve processing methods. A great deal of progress can be and has been made in such efforts, yet further developments in both better raw products and more suitable processing procedures are constantly sought by the canning industry and the various private and public institutions engaged in research work on such lines.

The texture or firmness of many canned plant products is of dominant importance in determining their commercial value. In certain canned fruits and vegetables, the texture or firmess comes to the fore in two major aspects; namely, (1) In its relationship to the retention of the original shape or size of the particles, and (2) in the behavior of the particles during the process of mastication. The former effect is mostly visual, while

the latter is essentially physiological inasmuch as the customer wishes the particles to show during chewing the extent and type of resistance which he rightly or wrongly associates with "quality" in the particular food.

The treatment of fruits and vegetables with calcium may enter into the quality picture through both of these avenues. Let us take stock now of the present status of the calcium treatment of canned fruits and vegetables.

Calcium Treatment of Canned Tomatoes

It is with great satisfaction that we feel justified in stating that the calcium treatment of tomatoes has become a standard practice in the canning industry. This does not mean that calcium is added to all canned tomatoes nor that this would be desirable. The benefits of the calcium treatment lie during a certain range of maturity of canning tomatoes when, with comparatively little prodding, one can induce this lovely fruit to do better than it would without treatment.

It is entirely clear now that the calcium treatment is of little help in case of tomatoes that would give an extensively disintegrated product when the normal procedure is used. Actually, in such cases the added calcium might cause the broken pieces of the tomato to attain some rather undesirable characteristics. Without being overly categorical, one may state that the maximum usefulness of the calcium treatment is in borderline cases where the use of this agent will ensure the production of essentially whole-canned tomatoes. The effect of added calcium on pieces of tomatoes put into a can is far from being as desirable as when the firming takes effect predominantly on the outside fleshy structures of essentially whole tomatoes.

Various Methods of Adding Calcium Suggested

When we first described the calcium treatment of canned tomatoes, two major alternate processes were listed; namely, the dipping of the peeled fruit into a solution of calcium chloride, and the addition of the calcium salt to the can. It is clear now that the advantages of adding the calcium to the can greatly outweigh those of the dipping process. The main factor enabling successful firming by the addition of calcium to the can is the presence of tomato juice in the can. This enables the calcium to reach all parts of the fruit and provides for uniform firming effect.

Again, for the addition of the calcium salt to the can, two methods were suggested; namely, addition in a solution (using tomato juice as a solvent), or in the form of dry (solid) calcium salts. While calcium chloride is added in a few plants in a solution, the overwhelming majority of users of the process prefer the addition of the calcium salt in the form of a combination table salt-calcium chloride tablet.

Developments in Calcium Tablets

Very soon after the benefits of added calcium in canned tomatoes became recognized, such combination salt-calcium chloride tablets appeared on the market. Table salt tablets now are used extensively in tomato canneries, and are likely to be used even more generally in the future. Therefore, the method of adding the calcium incorporated into a salt tablet may be the ultimate in convenience and efficiency.

However, a great deal of difficulty has been experienced with such tablets on account of the well known hygroscopicity of calcium chloride. The prospective usefulness of the tablets once they were taken from the sealed package was short on account of their rapid disintegration in the moist atmosphere of the canning plant. The use of small packages reduced this difficulty but did not eliminate it. Year after year we were looking forward to the appearance on the market of an improved combination tablet which would not be hygroscopic, but no such product was offered to the trade.

The obvious approach to cure this ill, then, was the development of the use of calcium salts which while permissible from the health standpoint, would not show the undesirable hygroscopicity. Even before the recent war several such attempts were made. They were brought to head in a hearing during the spring of 1947 when the then-existing standards of identity of canned tomatoes were changed to permit the use of several other calcium salts; namely, the sulphate, phosphate and citrate. Inasmuch as it was shown that the effectiveness of these salts depends on their calcium content and since now the allowable quantity is defined in terms of calcium, the canner has a number of different salt-calcium compound tablets available which eventually will take their appropriate place in the cannery according to the convenience and economies which they offer. As in any industry, the welfare of the tomato canning industry depends greatly on its over-all efficiency and, therefore, the appearance of better calcium-table salt tablets must be regarded as an important step forward.

Calcium Treatment of Canned Apples

In our early attempts to determine the usefulness of the calcium treatment of other canned products, we experimented with sliced apples. The results were very encouraging. After the end of the war, further work was started on this problem at Geneva as well as by the U. S. Department of Agriculture and the University of Massachusetts. The calcium treatment of apples presents some peculiar and interesting aspects.

The liquid content of a can of sliced apples is not sufficient to permit the addition of the calcium salt to the can. If this is done, excessive hardening will appear in the region where the calcium was added, while the firming may be nil in other parts of the can not reached by the calcium. It is interesting to note that there is a slow migration of calcium within a given slice of apple, but this process is too slow and incomplete to eliminate these difficulties. For this reason, the apples must be treated before they enter the can.

We have concentrated our work on two methods of treatment; namely, firming the apples during the period when they are soaked in salt solution and, second, by adding the calcium salt to the blanching water. It appears that either method can give very good results and will not necessitate additional operations with the possible exception of rinsing with water where the calcium compound is added to the blanching tank. Where neither treatment, during soaking or water blanching, is feasible, the firming might be accomplished by dipping the sliced apples into a solution of the calcium salt.

Apples Less Simple to Treat Than Tomatoes

Actually, the limitations of the calcium treatment of apples are more numerous than in the case of canned tomatoes. For one thing, it is somewhat more difficult to establish over-all proportions of calcium salt concentrations which will cause a satisfactory firming in the majority of cases. The different types of apples used in processing also seem to show much greater variation in texture characteristics and behavior than tomatoes. For this reason, the treatment used and the benefits derived will be peculiar to any given set of processing conditions and lots of the raw product. An over-all limit for calcium concentrations should be established in case of canned apples just as it has been done with tomatoes.

Inasmuch as in the case of canned apples a number of different methods might be used in the calcium treatment, it would appear that the upper limits should be defined in terms of calcium taken up by the tissue rather than by the concentrations of calcium salts in the treating solutions. Fortunately, the calcium treatment of apples is self-limiting just as in the case of tomatoes. Excessive treatment will leave an undesirable effect which one might designate as case-hardening.

Calcium Chloride May Cause Corrosion of Equipment

An interesting aspect of the calcium treatment of apples (and perhaps eventually of other plant tissues) is the possible effect of calcium chloride on processing equipment. It is known that hot solutions of chlorides under certain conditions may cause excessive corrosion of the processing equipment. We are not aware that this matter has caused any difficulties in canned tomatoes, but here, of course, the calcium salt is not in contact with the processing machinery.

In the case of apples the calcium treatment has to be performed prior to filling the containers, and for this reason some of the equipment is unavoidably in contact with the calcium salts. Since we found in our tests in 1938 that the efficiency of the calcium treatment depends predominantly on the proportion of calcium, we now are in the midst of an investigation of possible uses of various calcium salts other than the chloride for the treatment of the apples. There is also a possibility that some of these other salts might show some specific benefit in addition to a less severe effect on metal equipment.

In treating apple slices with solutions containing calcium salts, some control measure will have to be used to maintain the desired level of calcium in the solution. This can be done by determining the amount of calcium taken up per pound of apple, but we feel that an actual control of the calcium concentration in the solution will be simpler, more accurate and more dependable. Such tests to determine the calcium level in the treating solution can be easily developed, and will be made available when the legal status of this process is clarified. Similar simple tests are now used extensively in the canning industry.

Calcium Treatment of Other Fruits and Vegetables

During the past ten years we have investigated a long list of different fruits and vegetables for the possible benefit of using calcium salts in their processing. It also is known to us that similar tests with many canned products have been performed by various commercial organizations. Unfortunately, much of this information is not generally available, although it is likely that many further instances of useful application of the calcium treatment exist.

Calcium treatment tests with pears generally gave discouraging results. The type of firming obtained is of doubtful benefit inasmuch as it is different from the texture one expects in canned pears. The situation is much better with peaches, where in certain cases very desirable firming could be induced by dipping the peaches immediately after peeling into a dilute solution of calcium chloride. As might be expected, the addition of a small proportion of ascorbic acid to the soaking solution improved the appearance of the peaches although the calcium dip in itself reduced the browning of peaches as well as that of apples. The main difficulty with peaches is that the most objectionable damage to the tissue is likely to occur during the peeling operations, and the subsequent calcium treatment will prevent further damage but will not repair the frizzled edges.

Calcium treatment has been shown to be of benefit to many other fruits under certain conditions. Strawberries and other small fruits can be firmed effectively and their disintegration retarded through calcium treatment. Great care has to be exercised in such cases to avoid a "leathery" product. Calcium salts have been in use for many years in the firming of Maraschino cherries. Calcium also has been used successfully in the preparation of cherries for canning; here it proved to be beneficial in preventing the excessive tearing of the tissue during the pitting operation. There are many cases where benefits are derived by firming the tissues under certain conditions, mainly in reducing excessive softening and disintegration during heat processing.

Firming Effect Not Always Desirable

There are comparatively few vegetables where firmness as such is desirable. With canned peas and beans, the usual problem is to counteract the firmness caused by the calcium and magnesium contained in hard water, and calcium sequestering agents as polyphosphates have been used in such cases with success. On the other hand, there are cases when calcium salts are used in connection with canned peas. In the Blair process and its later analogues, calcium and magnesium are used in part for the maintenance of the firmness of the green peas during processing.

Calcium salts also have been used with some success in the firming of asparagus tips to prevent disintegration during cooking. The undesirable softening and sloughing off of potatoes during canning also can be efficiently counteracted by a short dip into a solution of calcium chloride. The concentrations used in such treatments are about ten times as high as those used when fruits are firmed. There is some doubt whether the mechanism of the firming action in potatoes is similar to that in fruits. The effect of the calcium in bettering the appearance of the canned potatoes from the standpoint of "gloss" and color is also quite obvious.

Present Legal Status of the Calcium Treatment

The calcium treatment of tomatoes has been permitted since 1940, when the National Canners Association, in collaboration with a number of other organizations, took the necessary steps leading to the legalization of the process. The recent revision of the amendment to the standard of identity to include calcium compounds other than the chloride was primarily the result of the initiative of the Morton Salt Company. A number of other organizations collaborated. Fortunately, the detection of the calcium treatment in canned tomatoes is very simple and unmistakable, an argument which was used effectively in arguing for a revision of the standard of identity.

The situation is quite different with the calcium treatment of canned apples. I shall not be so foolhardy as to state whether the use of calcium in this case is legal or not, but it is only fair to state that the situation is rather confused. It is at least possible that some producers already may be using the calcium treatment, while others are reluctant to do so. The detection of the calcium treatment in apples is no more difficult than it is in the case of tomatoes.

Once, when a processor was reminded of the questionable legality of using a calcium chloride solution on a certain product, he replied that this cannot be objectionable since it only increases "somewhat" the hardness of the water used. Surely, it is unnecessary to point out the transparency of such an argument.

Further Steps Necessary to Make Process Available

We have conclusive indirect evidence that many processors share our view that the calcium treatment is often of benefit in canned apple slices. The process, therefore, should be available to the industry. It is up to the packers of this product to see to it that somebody takes the lead and shoulders the burden and expense of attaining this goal. Remembering the reasonable and helpful attitude of various authorities toward the similar proceedings dealing with canned tomatoes, one should not anticipate any major difficulties in making the calcium treatment of apples an optional process. Actually, the evidence on the benefits of the calcium treatment of canned apples is considerably more extensive and systematic than what we had on hand in 1940 in the case of tomatoes.

At Geneva we are ever on the lookout to find improvements in raw products and processes which will result in better food products. It also is our duty and desire to cooperate with various organizations in taking steps towards making such improved processes available to the canning industry.

PROCESSING FOODS IN GLASS CONTAINERS

By W. B. Esselen, U. of Mass., M. J. Powers, Owens-Illinois, C. T. Townsend and J. M. Reed, N.C.A.

Introduction

In the canning industry, an essential function of research laboratories for many years has been the establishment of minimum safe processes. By a "minimum safe process" is meant the heat treatment, applied to a container of food after it is hermetically sealed, which is sufficient to insure destruction of the most heat resistant spores of *Cl. botulinum*. In the development of such processes, extensive experimental work often is necessary, involving heat penetration measurements, thermal death time determinations, and inoculated experimental packs.

Until comparatively recently, most of the work on process determination has been carried on in the laboratories of the can companies and the National Canners Association. Throughout the years a great deal of data have accumulated on foods packed in tin, and the fruits of this work are contained in Bulletin 26-L, "Processes for Low Acid Foods in Metal Containers," published by the National Canners Association. Only processes approved by all participating laboratories are included in this bulletin, which is revised every few years as additional data are obtained. The first edition was published in 1930, and the present edition is the Sixth. Each year a processing conference is held with representatives of all participating laboratories in attendance. Data obtained during the year are discussed, and decisions are reached as to whether they should be accepted or whether further work is needed. Projects then are assigned to each laboratory for the ensuing year.

During the war years, and since that time, interest among commercial operators in the use of glass for canning has increased steadily. Since little information was available on the rates of heat penetration in glass-packed foods, it was customary to use the same processes as for the corresponding sizes of tin cans, with an additional five minutes as a safety factor. There was considerable dissatisfaction with this procedure, and the matter was brought to a head in 1945 by a request from the California State Department of Public Health for process recommendations for all low-acid foods packed in the various sizes of glass containers.

Research Program Set Up

A committee of interested persons was formed in San Francisco, and it was decided to ask the Glass Container Manufacturers Institute to consider sponsoring a fundamental study of the rate of heat transfer in various types of products packed in glass containers. They agreed to do this, and to make available equipment and additional personnel for a cooperative investigation to be undertaken by the National Canners Association. The object of the investigation was to obtain basic data on rates of heat penetration in glass as compared with tin, with a view to the eventual publication of a bulletin, similar to N.C.A. No. 26-L, giving recommended safe processes for low-acid foods packed in glass. It also was hoped to obtain sufficient data to determine in what manner, if any, it was necessary to modify C. Olin Ball's mathematical procedure for the calculation of processes for foods packed in metal containers to make it applicable to foods packed in glass.

Organization of the Research Program

The work was carried out at the San Francisco Laboratories of the National Canners Association, with the following personnel:

For the Glass Container Manufacturers Institute—

W. B. Esselen, University of Massachusetts, J. E. W. McConnell, University of Massachusetts, and M. J. Powers, (Loaned by the Owens-Illinois Glass Co.).

For the National Canners Association, Washington, D .C.—

J. M. Reed and J. J. Dwyer.

For the National Canners Association, San Francisco, Calif.—

I. I. Somers, and Nelda Zuch, assisted by other members of the staff.

For the University of California, Laboratory for Research in the Canning Industries—

C. T. Townsend.

Preliminary Studies

Because so many data are available on rates of heat penetration into foods packed in tin, it was deemed advisable to compare heat penetration rates in glass jars and tin cans of corresponding sizes, with the hope that some factor or factors might be developed which could be used in applying can data to jars. The following sizes were selected for study:

Container	Dimensions	G.C.M.I. No.	Capacity fluid oz.
Baby jar	200 x 309	.....	5.1
Junior jar	208 x 401	.....	8.1
No. 303 jar	303 x 411	15-53	17.0
No. 2½ jar	401 x 414	15-71	28.3
Baby can	202 x 214	.....	4.8
Junior can	211 x 210	.....	6.5
No. 2 can	307 x 409	.....	19.7
No. 2½ can	401 x 411	.....	28.6

No. 2 cans were chosen for comparison with No. 303 jars because No. 303 cans (303 x 406), were unobtainable.

It was decided to study three tyes of heat transfer—convection; conduction; and "broken curve", in which the heating is initially by convection, changing to conduction at some point in the heating cycle. In an attempt to obtain as nearly reproducible results as possible, suspensions of bentonite were used to fill the containers. Cans were filled completely, while a headspace of one-half inch was allowed in jars. One percent bentonite was used for convection heating, and five percent for conduction heating. Several intermediate concentrations were investigated in an attempt to obtain a heating curve with a break at a constant time interval in each test, but results were so erratic that no further work was done on broken curves. One percent and five percent bentonite suspensions were found to be sufficiently stable for the purposes of the experiments, withstanding at least ten successive processes without appreciable change in heating characteristics, provided that two stabilizing processes were given first.

Considerable time was spent in developing a hermetic thermocouple rod and in determining how to introduce the thermocouple rods into the jars without the possibility of leakage during the process. Satisfactory thermocouple rods were finally made by molding bakelite around 24-gauge duplex copper constantan wires in "Fiberglas" insulation. These rods were introduced into jars and cans through packing glands soldered to the lids. It was found that leakage could be prevented in jars during the process by the use of White Caps held on with specially designed clamps.

A large number of runs were made to determine the point of slowest heat penetration in each size of jar processed in each of three positions—cap up, cap down, and horizontal. These slowest heating points were used in all subsequent experiments.

Preliminary studies on the effect of jar position in the retort on the rate of heat penetration indicated in the case of one percent bentonite a somewhat faster heating rate for jars when processed in a horizontal position or with caps down than when processed with caps up. Since the heating rate of jars processed in a horizontal position was almost identical with that for jars processed caps down, only two positions were chosen for subsequent runs with one percent bentonite—caps up and caps down. Position appeared to have no appreciable effect in the case of five percent bentonite, and all jars containing five percent suspensions subsequently were processed caps up. All cans were processed in a vertical position.

Consideration was given to a possible increase in lethality with one percent bentonite cooled slowly as compared to the same suspension cooled rapidly. With cooling times of ap-

proximately 5 and 12 minutes, no significant difference was observed in the cooling rates except toward the end of the cooling cycle, when the lethality was little affected.

General Runs

With the preliminary studies completed and technique established, attention was concentrated on the following problems:

(1) Comparison between heating rates in jars and cans of corresponding sizes.

(2) Effect of position of jars on the heating rate.

(3) Effect of long (approximately 20 minutes) as compared to short (approximately 5 minutes) come-up times on the lethality of processes.

(4) Effect of steam as compared to water as a heating medium.

Baby and junior jars and cans were processed together, as were No. 303 and No. 2½ jars, and No. 2 and No. 2½ cans. Three containers of each size were included in each run. When the filling medium was one percent bentonite, three jars of each size were processed with caps up and three with caps down.

When each retort load of containers was prepared, three runs were made, at 250° F., 240° F., and 212° F., with a come-up time of 5 minutes. The retort was not opened between runs. When one percent bentonite was used, two additional runs were included, at 250° F. and 240° F., having a come-up time of approximately 20 minutes. In all runs the initial temperature of the one percent bentonite was about 130° F. and that of the five percent bentonite was about 150° F. Processes for the one percent bentonite series were continued until the indicated temperature in the slowest heating container was the same as that of the retort. The process time varied from about 9 minutes for the baby size to 20 minutes for the No. 2½ containers. For the five percent bentonite series, process times were 40 minutes for the baby and junior sizes, and 120 minutes for the larger sizes. The cooling time in all runs was approximately 5 minutes for the temperature of the water in the retort to drop 100° F.

At the end of each series of runs, a new set of containers, with a new bentonite suspension and different thermocouples, was substituted, and the series was repeated.

Heat penetration data were evaluated in terms of lethalities by the general (graphical) method, using a z value of 18. For purposes of comparison, processes for the one percent bentonite suspensions were calculated which would give F_0 or F_{18} values of 8.0 (lethality of come-up and cooling time included). Slopes of the heating curves (f_h) and j values were also obtained.

This talk is too short to give comparative data in detail, and results therefore are expressed only in general terms. A paper giving a complete report of the investigation is now being prepared, and it is hoped to have this published in a technical journal.

Discussion of Results—One Percent Bentonite

With the exception of baby jars, processing jars in the cap down and horizontal positions appears to give a somewhat more rapid rate of heat penetration than processing in the cap-up position. This indicates that positions in which the contents of the jar are in contact with the metal cap result in a somewhat faster rate of heat transfer than that in which there is a headspace between the contents of the jar and cap. For processes calculated to give F_0 or F_{18}=8, the advantage in favor of the cap-down and horizontal positions is between one and two minutes. This difference does not appear to be sufficiently great to warrant process recommendations for jars processed in different positions, and the cap-up position should be chosen as representing the condition of slowest heat penetration.

In terms of process times required to give F_0 or F_{18}=8, come-up times of about 20 minutes have a significant effect as compared to come-up times of about 5 minutes. At both 240° and 250°F. this difference in favor of the longer come-up time is about 1 minute for baby jars and 3½ minutes for No. 2½ jars processed with caps up. The effect is not so pronounced in the case of cans. The percentage of the come-up time which may be applied as process time is being investigated mathematically.

Under conditions of convection heating, jars appear to heat more slowly than cans of corresponding sizes, although this difference is less when the jars are processed with caps down than with caps up. The larger the container size, the greater appears to be the difference. The results indicate that the 5-minute safety factor added to processes for cans to make them applicable to corresponding sizes of jars may not be adequate for jars containing convection heating products. Present indications are that the increase should be approximately 10 to 15 minutes.

Heat penetration data indicated no difference in the heating rates of cans processed in steam and in water.

Discussion of Results—Five Percent Bentonite

The heating rate as indicated by f_h values in all sizes larger than the baby size is somewhat faster for cans than for jars. This results in a somewhat greater lethality for a given process for cans than for jars of corresponding sizes, with the exception of the baby size. It was expected that jars would cool more slowly than cans, thus compensating to some extent for the slower heating rate. This was found not to be the case, the jars nearly always cooling faster than the cans. It was shown that rapid cooling of 5% bentonite in jars or cans can be brought about by high vacuum and adequate headspace. In normal operations, however, cans are closed with little or no headspace, while a headspace of about one-half inch is allowed in jars, which are sealed with a higher vacuum than cans. When the vacuum starts to form in the jars during the cool, boiling of the contents frequently occurs, and with this agitation of the contents, the jars cool rapidly. In cans there is normally little or no headspace after sealing, and the ends become bulged during the process. During cooling, however, the ends become concave again as soon as sufficient vacuum is formed. Consequently, boiling does not occur as a rule and cans therefore cool more slowly than jars of corresponding size. Based on results with bentonite, processes for No. 303 jars should be approximately 5 minutes longer, and for No. 2½ jars approximately 15 minutes longer than corresponding sizes of cans.

Mathematical Analysis of the Data

A detailed analysis of the data was undertaken to determine if C. Olin Ball's calculation method of process determinations for foods packed in metal containers could be so modified as to be applicable to glass-packed foods. This study has been completed, and it is now possible to apply the calculation method to thermal death time and heat penetration data for establishing processes for foods packed in glass.

There is some question at the present time as to the extent to which conversion factors obtained with bentonite may be applied to food products.

Experimental Packs

During the summer of 1947, a series of inoculated experimental packs was made as a further check on the work with bentonite. In all cases, cans of corresponding sizes were processed with the jars, and heat penetration measurements were made on both containers. The following products were included:

Strained pea soup in baby jars and cans.

Strained mixed vegetables with bacon in baby jars and cans.

Chopped mixed vegetables with chicken in junior jars and cans.

Peas in brine in No. 303 jars and No. 2 cans.

Whole grain corn in brine in No. 303 jars and No. 2 cans.

The results check the work with bentonite closely, in that somewhat longer processes were found to be necessary for products packed in glass than in tin.

Process Bulletin for Low Acid Foods Packed in Glass

Plans are underway for the preparation of a bulletin giving recommended processes for low-acid foods packed in glass containers, similar to National Canners Association Bulletin No. 26-L, giving processes for low-acid foods packed in metal containers. Processes will be recommended for four sizes of jars—baby, junior, No. 303, and No. 2½. In addition, there will be diagrams and specifications for hook-ups for both vertical and horizontal retorts, with directions for their operation. It is hoped that a first edition of this bulletin can be published in 1948.

INFLUENCE OF PACKING CONDITIONS ON THE PROCESS REQUIREMENTS OF VACUUM PACKED WHOLE KERNEL CORN

By W. H. Wade and H. A. Benjamin, American Can Co.

Introduction

The vacuum packing of vegetables has come into extensive use since the invention of the method 20 years ago. Vacuum packing of the yellow varieties of whole grain corn has met with particular success and in 1945 approximately 40 percent of the whole grain corn pack was canned by this method. Essentially, the vacuum procedure is based on the principle that the creation of a high vacuum in the can permits the use of a minimum amount of added water or brine which in the absence of other gases can vaporize to carry the necessary sterilizing heat from the container surfaces to the food particles. This eliminates the need to fill the can with a brine to transfer heat rapidly to the kernels of corn. In addition to affording the consumer a vegetable almost free of cooking liquid, vacuum packing facilitates the utilization of all the water-soluble vitamins and minerals which are often discarded in brine-packed vegetables.

Cans of a size nominally designated as 307 x 306 generally are used for this product. Processes recommended are equivalent to 35 minutes at a retort temperature of 250° F., a process established some years ago by heat penetration tests. In Bulletin 26-L, the National Canners Association Laboratory specified certain conditions of fill, added brine, and vacuum as being important to the success of the recommended processes. These conditions are: (1) A maximum fill of 11¼ ounces of corn, (2) a minimum quantity of one ounce of added free liquid, and (3) a minimum can vacuum of 23 inches before processing.

Many factors, individually or in combination, have a direct or indirect influence on the efficiency of a sterilizing process at any given time and temperature. The factors which apply specifically to vacuum packed corn and which will be discussed in this paper are:

(1) Fill-in weight, (2) the amount of added liquid, (3) maturity of the corn, and (4) can vacuum.

Experimental Methods

In the studies reported here, heat penetration tests were made using fills of 10 ounces, 11¼ ounces and 12½ ounces in 307 x 306 size cans for each of three maturities of corn; namely, young corn, corn of average maturity, and mature corn. All samples were hand-packed as nearly alike as possible. The amount of corn that may be filled into a can of any particular size varies with the maturity, size, and shape of the kernels. The more mature the corn, the more difficult it becomes to fill a given weight into the can.

TABLE I

Moisture Content by Modified Brown-Duval Method and from Alcohol Insoluble Solids (AIS) Tests

Alcohol Insoluble Solids	Moisture (Brown-Duvel)	Moisture from Kramer and Smith AIS Data
Percent	*Percent*	*Percent*
17.5	74.0	73.7
15.5	76.5	77.0
15.0	76.5	77.9
16.4	73.5	75.0
18.0	75.0	73.0
17.0	74.0	74.4
15.8	76.0	76.4
16.8	76.0	74.4
19.7	75.0	70.6
15.9	73.5	76.2
16.8	73.5	74.7
17.5	75.0	73.7
20.7	71.5	69.3
22.4	68.0	67.2
21.3	69.0	68.5
20.1	69.5	70.1
20.6	69.5	69.4
21.8	68.0	67.9
19.4	71.5	71.0
20.7	71.0	69.3
21.2	69.0	68.7
24.2	66.5	65.0
25.2	68.5	63.9
24.4	69.0	64.8
23.1	66.5	66.3
22.8	66.5	66.7
19.8	66.5	70.5
24.5	66.5	64.7
23.9	66.5	65.3
24.5	66.5	64.7
22.9	68.0	66.5
23.5	68.0	65.8
23.4	68.0	66.0
21.9	67.5	67.0
22.7	67.5	66.8
23.2	67.5	66.2

A weight of 11¼ ounces of corn of average maturity was about the maximum that could be hand filled into a 307 x 306 size can without considerable mashing or squeezing of the kernels. A fill-in weight of 11¼ ounces of mature corn or more than 11¼ ounces of corn of average maturity in a 307 x 306 size can would appear to offer a difficult commercial production problem. With a few exceptions, brine variables from none to 60 milliliters were used in increments of 15 milliliters for each of the fill-in weights used and for each of the maturities tested.

Maturity Tests

Maturity of the corn was judged by moisture tests made using a modified Brown-Duvel moisture determination method. These values were confirmed later by alcohol-insoluble solids determinations upon companion samples. The data of Kramer and Smith[1] were used to check the moisture values and, with only a few exceptions, the moisture values checked within 2 percent. The alcohol insoluble solids data are tabulated in Table I. The corresponding percentages of moisture, determined by the modified Brown-Duvel method and those interpolated from the Kramer and Smith data, also are shown in this table.

Corn of the following moisture content was sought as being representative of the maturities desired for this particular hybrid corn:

Corn Maturity	Moisture Content
	Percent
Young	Greater than 73
Average	68-73
Mature	Less than 68

Nine cans comparable to those used for the determination of moisture were used for obtaining heat penetration data of each variable. The data from the slowest heating can were used for calculation of the sterilizing efficiency of the process. The maximum difference between the lowest and highest sterilizing values, obtained in any one run, was three F. units. The average difference in all runs was approximately two F. units. Thermocouples were located consistently in the geometrical centers of the cans. In all runs, the cans were closed under 26 inches of machine vacuum and were held 15 minutes before processing. After cooling, vacuum readings were taken on all cans containing thermocouples and on several comparable

[1] "The Succulometer, an Instrument for Measuring the Maturity of Raw and Canned Whole Kernel Corn," *The Canner*, p. 11, June 1, 1946.

TABLE II

Relation of Fill Weight and Added Liquid to Heat Penetration in Vacuum Packed Whole Kernel Corn (307 x 306 Cans)

Sterilizing Value (F_s) for 35 minutes at 250°F

Fill oz. av.	Added Liquid ml.	Young Corn	Average Corn	Mature Corn
10	0	11.3	Not run	9.9
10	15	Not run	Not run	9.5
10	30	12.0	14.2	9.4
10	45	13.2	14.6	11.2
10	60	13.2	13.5	12.0
11¼	0	4.2	Not run	9.9
11¼	15	Not run	Not run	7.5
11¼	30	6.1	7.5	9.5
11¼	45	8.5	9.4	6.9
11¼	60	10.1	11.0	11.7
12½	0	1.6	Not run	1.5
12½	15	Not run	Not run	3.0
12½	30	2.1	6.5	2.9
12½	45	7.4	7.3	7.1
12½	60	7.1	10.3	9.0

cans which served as controls. Any can which contained a thermocouple and which had substantially a lower vacuum than the similarly packed cans without thermocouples was assumed to have a leaky thermocouple fitting and the data from such a can were rejected. Other samples, similarly packed and processed, were examined for headspace, drained net weight, and the amount of free liquid after processing.

The sterilizing values (F_s) for processes of 35 minutes at 250° F. for the slowest heating can of each test made are given in Table II.

Findings

The Effect of Fill-in Weight—The data in Table II definitely show a decrease in the sterilizing values obtained with increased fill-in weights of corn. The maximum difference in the sterilizing values, obtained when the fill-in weight was varied from 10 to 12½ ounces, was obtained with young corn and using 30 milliliters of added liquid. Under these conditions the F_s value decreased from 12.0 to 2.1. The minimum difference in sterilizing value, with respect to fill-in weight increase, was with corn of average maturity and the use of 60 milliliters of added liquid. With these conditions the F_s value decreased from 13.5 to 10.7. It is obvious that other factors are very closely related to the sterilizing values obtained with over-filled cans. However, the general conclusion that increasing the fill-in weight decreases the sterilizing value of a given process, when other conditions are similar, seems justified. In the discussion of the other factors studied, their relationship to overfilled cans will be pointed out.

The effect of fill-in weight can be demonstrated in terms of the required process time as well as in terms of sterilizing value. This has been done in Table III for the selected conditions of young corn with a standard 11¼ ounce fill and an overfill. It will be noted that the data indicate that with 45 or more milliliters of liquid, the overfill could be compensated for by a five-minute increase in process time. However, with only 30 ml. of liquid a substantial increase in process was indicated if the fill is increased to 12½ ounces.

TABLE III

Relation of Fill-in Weight to Calculated Equivalent Process Time for Young Corn

Added Liquid ml.	Fill Oz. Av.	Calculated Equivalent Process Time at 250° F. Min.
30	11¼	35
	12½	52
45	11¼	35
	12½	37
60	11¼	35
	12½	40

TABLE IV

Relation of Corn Maturity to the Ratio of Drained Liquid to Added Liquid

Maturity	Ratio of * Drained Liquid to Added Liquid
Young	.92
Average	.81
Mature	.63

* These figures are average of data from all cans in tests including 30 to 60 ml. of added liquid and 10 to 12½ ounce fills of corn.

The Effect of Added Liquid—In nearly all cases, increasing the amount of added liquid increases the sterilizing value of a given process, when other factors remain the same.

The greatest change caused by increasing the volume of added liquid occurred with cans overfilled with 12½ ounces of mature corn. The variation in F_s values obtained here was from 1.5 with no added liquid, to 9.0 with 60 milliliters of added liquid. In general, it can be said that increasing the added liquid was more effective in increasing the sterilizing value in cans in which the corn was tightly packed.

The Effect of Maturity—The effect of the maturity of the corn on the sterilizing value appears to be of much less significance than that of the fill-in weight or the amount of added liquid. The greatest effect of the maturity of the corn may be the changes necessitated in the fill-in weights, the added liquid used, and other factors which affect the rate of heat penetration. Older corn absorbs more moisture than does younger corn, as is indicated by the data in Table IV, and so requires a higher ratio of liquid to corn. The customary practice is to fill less corn and add more liquid to the more mature product. Since decreased fill-in weights and increased added liquid have been shown to increase the sterilization value of any given process, the packing of older corn does not present the same hazard of under-sterilization as young corn if these fill adjustments are made.

In Table IV are shown ratios of the drained free-liquid to added-liquid for the different maturities of corn used. These are average values obtained from all cans in the tests including 30 to 60 milliliters of added liquid and 10 to 12½ ounce fills of corn. The ratios of drained-free-liquid to added-liquid for each variable based on the results of three cans for each condition are given in Table V.

Referring again to Table II, it might be noted that for all maturities and all fill-in weights used for added liquid volumes of 30 milliliters or more, all but two variables have sterilizing values (F_s) of 6.1 or better, which is the value obtained under conditions recommended by National Canners Association Bulletin 26-L. These two exceptions are the F_s value of 2.1 obtained with 12½ ounces of young corn and 30 milliliters of added liquid, and the F_s value of 2.9 obtained with 12½ ounces of mature corn and 30 milliliters of added liquid. With 12½ ounces of corn of average maturity and 30 milliliters of added liquid, an adequate sterilizing value (F_s) of 6.5 was obtained.

The only apparent explanation for these results is that the younger corn mats, and even though its ratio of total moisture to corn is greater than that of average corn, the heat cannot penetrate between the kernels of corn so readily. With older corn, the kernel size is so large that in order to contain 12½ ounces of corn, it must be compressed very tightly. This, plus the fact that in old corn the ratio of total moisture to corn is lower than that of corn of average maturity, may account for its lower rate of heat penetration. In other words, corn of average maturity is of such particle size that it is large and firm enough not to mat and is sufficiently heavy so that extreme compression is not necessary

to meet a fill-in weight of 12⅛ ounces even though such weight may be difficult to obtain under commercial operating conditions.

The Effect of Can Vacuum—The measurement of the effect of can vacuum on heat penetration was included as part of this experimental program. Circumstances did not permit the completion of this phase of the work and, consequently, a report of the effect of this factor must await further work which is contemplated.

Random observations made over several years have indicated that the closing vacuum has an important influence on the sterilizing value of the process. With a closing vacuum of 10 inches the sterilization value of a standard N.C.A. process has been found to be reduced to approximately one third of its value with 26 inch vacuum closure. There is evidence that enzymatic production of gas during the period between closing and processing, causing a reduction in can vacuum, may also have an effect on the sterilizing value of the process. In Bulletin 26-L, the National Canners Association Research Laboratory recommends a minimum can vacuum of 23 inches before processing. A general recommendation also is made that processing should follow within one-half hour to one hour after closure. With vacuum packed corn, experience has shown that it would be well not to exceed the one-half hour holding period. The temperature at which the closed cans are held is probably an important factor in enzymatic production of gas during holding after closure and this will also be a subject of future study.

Summary

The general conclusions regarding the sterilizing values obtained in processing vacuum packed whole grain corn which appear warranted from the data obtained in these studies are as follows:

1. Within specified limits, increasing the fill-in weight decreases the sterilizing value of any given process.

2. In the range of 0 to 60 ml., increasing the amount of added liquid increases the sterilizing value of any given process.

3. The greatest effect of maturity of corn is that it changes other factors which in turn affect the sterilizing value obtained with a given process.

4. Further work on the effect of can closing vacuum and time of holding before processing on the sterilizing value obtained with a given process is desirable and is contemplated.

Considering all factors discussed, the most serious obstacle to obtaining adequately sterilized corn occurs when small quantities of brine are added to overfilled samples of young corn. With the heavier fills, the data obtained indicate that the minimum added water requirement should be 45 milliliters per 307 x 306 can.

TABLE V

Variations in Drained Free Liquid to Added Moisture Ratios in Vacuum Packed Corn

Corn Maturity	Fill-in Wt. (oz.)	Added Liquid (ml.)	Ratio* Drained Liquid: added liquid
Young	10	30	.97
"	11⅛	30	.81
"	12½	30	1.00
"	10	45	1.02
"	11⅛	45	.98
"	12½	45	.78
"	10	60	.97
"	11⅛	60	.97
"	12½	60	.89
Average	10	30	.87
"	11⅛	30	.90
"	12½	30	.80
"	10	45	.94
"	11⅛	45	.92
"	12½	45	.80
"	10	60	.73
"	11⅛	60	.66
"	12½	60	.83
Mature	10	30	.37
"	11⅛	30	.66
"	12½	30	.44
"	10	45	.68
"	11⅛	45	.71
"	12½	45	.64
"	10	60	.80
"	11⅛	60	.75
"	12½	60	.60

* Average of data from three cans for each condition.

SPOILAGE CONTROL PROCEDURES FOR TOMATO JUICE

1. Preliminary Statement

By E. J. Cameron, Director, Washington Research Laboratory, N.C.A.

There is no secret about the spoilage in tomato juice which occurred in the East in 1947. Neither is there any lack of information on the fact of the occurrence of spoilage in canned tomatoes in the same area.

This much is known. But as to the cause of this spoilage, the nature of the spoilage organisms, and the mechanism of introduction into the product, there has been such a flood of rumors, speculation and pseudo-scientific utterance, that the relatively simple basic facts of the problem have been badly fogged. As a result, the canner of tomato juice in the area which was most affected is understandably bewildered and perhaps overly apprehensive about the future. Moreover, as a result of certain ill-advised statements alleging ignorance on our part and the part of others concerning the cause of spoilage, the canner may wonder where and to whom he may look for technical guidance next season. Therefore, I want to emphasize now that we knew the cause of spoilage within a few days after the first samples were received and that there was nothing new in this information.

In 1934, our Laboratory investigated an outbreak of heavy spoilage in tomato juice. The organism which was isolated as the cause of spoilage was that described by Berry and named by him *B. thermoacidurans*. We found that the organism developed overnight in equipment and the contamination was heaviest in the first canning period of the day. Two hours after starting, this equipment contamination was reduced to the point where spoilage did not occur. As a result of our work, we devised a somewhat empirical but nevertheless informative control procedure which will later be redescribed by Mr. Bohrer.

So far as our information goes, there were two types of spoilage in the 1947 juice pack and two types of spoilage in canned tomatoes. One organism, that which produced swells in tomato juice, apparently was common to both. The flat sour type of spoilage was found by us only in tomato juice.

In at least two operations, the spoilage was heaviest during the latter part of August when tomato receipts were very heavy, possibly at the peak. This has led some observers to suggest, and in some cases even to assert, that the contamination was present in sufficient amount in the tomatoes at the time they came to the plant to explain the spoilage which subsequently took place. In view of our past experience in questions involving spoilage control in tomato juice, we do not subscribe to this theory of spoilage, and from some observations which we

have made, we are firmly of the belief that equipment contamination carried a major responsibility in the 1947 spoilage and somehow was tied in with the peak operations. We believe, further, that had the bacterial condition of the tomatoes been responsible, the spoilage would have extended far beyond the area which actually was most affected.

We have made a lot of study recently of the organisms involved in this spoilage, and more will be done before the next pack. Particularly, we have made heat resistant studies, the results of which will be used in arriving at recommendations for high temperature sterilization. Aside from that, however, we have been giving attention to considerations relating to spoilage control through maintenance of low contamination. Mr. Bohrer will outline our control procedures.

Prior to the next pack, contact will be made with each one of our members in and adjacent to the 1947 spoilage area, and each member will be offered the service of our field laboratories during the pack. Where the service is wanted, periodic checks will be made on samples to determine the condition of the equipment. Advice will be given on control procedures, and, in short, we will do all that we possibly can to prevent a recurrence of last year's experience. We recognize that the job will be a heavy one and that it will require the major effort of the season. With our trained staff and background of experience, however, we believe that adequate coverage of our membership can be accomplished.

SPOILAGE CONTROL PROCEDURES FOR TOMATO JUICE

2. Control Procedures

By C. W. Bohrer, Washington Research Laboratory, National Canners Association

Experience has indicated that the bacteriological condition of tomato juice canning equipment during packing operations can be a factor in tomato juice spoilage. The maintenance of a satisfactory bacteriological condition at all times, therefore, is of major importance. A number of investigators, among them E. J. Cameron, O. B. Williams, and W. E. Pearce and E. H. Ruyle, have recommended precautionary measures to prevent excessive contamination of the product with spoilage types.

Precautions Summarized

The following is a brief review of the basic recommendations which have been suggested to supplement the usual clean-up practices in all canning factories handling tomato juice. Physical cleanliness of the equipment should be ensured by careful supervision of all clean-up procedures. After the night clean-up, the equipment should be flushed with hot water and then cooled by flushing with cold water. Before the start of operation, the equipment should be flushed again with hot water. This will serve the dual purpose of cleaning and raising equipment temperature to operating levels.

During packing operations, strong sprays of water should be used in washing the tomatoes, and the soak tank water should be changed at least twice daily. The use of wooden equipment in contact with the tomatoes or juice should be avoided. Pumps, pipe lines, and fillers should be dismantled and cleaned as frequently as practicable.

Whether these precautionary measures are effective in eliminating spoilage hazards for a particular situation or whether they are being applied with the thoroughness originally intended can be ascertained by the use of check procedures.

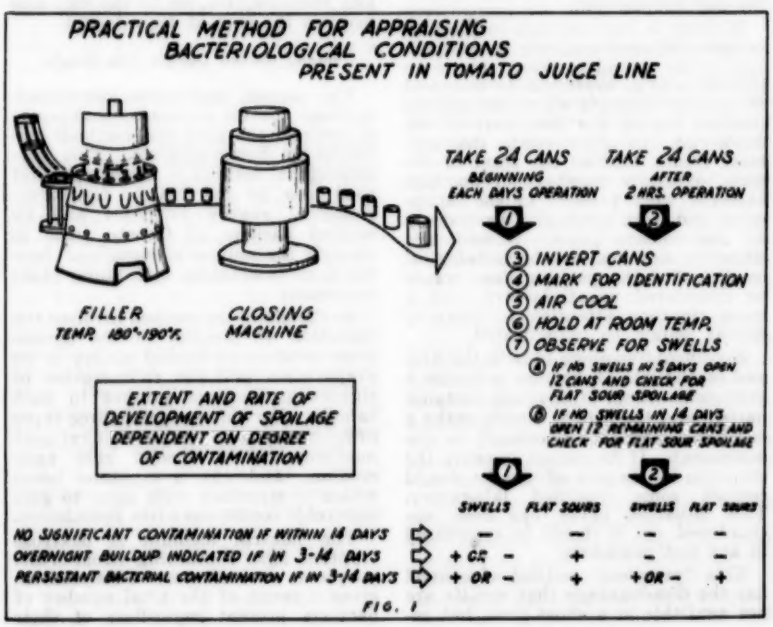
Check Procedures

Two procedures may be employed to appraise the bacteriological condition of tomato juice equipment. One is concerned with the daily observation of a number of cans of tomato juice selected and held according to certain specifications. The other involves the use of bacteriological techniques designed to detect the location and magnitude of significant bacterial contamination.

The first, somewhat empirical incubation method was outlined by E. J. Cameron in 1935. This method was described in several trade journals, such as *The Canner*, *Canning Age*, and *Canning Trade*. Since then, it has been in use by a number of canners with apparently satisfactory results. Although the procedure was originally intended for use with conventional juice lines, utilizing relatively low filling temperatures and a still process in water, it also can be used with lines utilizing presterilization units or other high-filling temperature systems. The mechanics of this test procedure are shown schematically in Figure 1 and the detailed suggestions for its conduct are repeated as follows:

SAMPLING:

1. Take 24 cans daily at the start of packing operations. If presterilization or some other hot fill system is used, take the first 24 cans through the closing machine and water cool them to approximately 100° F. If a conventional still process system is used, take 24 cans as soon as the filling temperature reaches 180° F. to 190° F. Invert the cans and allow them to air cool. Under no circumstances should samples be taken before 180° F. is reached because the temperature should be high enough to destroy all bacteria not in the spore form.


PRACTICAL METHOD FOR APPRAISING BACTERIOLOGICAL CONDITIONS PRESENT IN TOMATO JUICE LINE
TAKE 24 CANS BEGINNING EACH DAYS OPERATION
TAKE 24 CANS AFTER 2 HRS. OPERATION
1
2
3 INVERT CANS
4 MARK FOR IDENTIFICATION
5 AIR COOL
6 HOLD AT ROOM TEMP.
7 OBSERVE FOR SWELLS
IF NO SWELLS IN 5 DAYS OPEN 12 CANS AND CHECK FOR FLAT SOUR SPOILAGE
IF NO SWELLS IN 14 DAYS OPEN 12 REMAINING CANS AND CHECK FOR FLAT SOUR SPOILAGE
FILLER TEMP. 180°-190°F.
CLOSING MACHINE
EXTENT AND RATE OF DEVELOPMENT OF SPOILAGE DEPENDENT ON DEGREE OF CONTAMINATION
1 SWELLS
1 FLAT SOURS
2 SWELLS
2 FLAT SOURS
NO SIGNIFICANT CONTAMINATION IF WITHIN 14 DAYS — — — —
OVERNIGHT BUILDUP INDICATED IF IN 3-14 DAYS + OR − + − −
PERSISTANT BACTERIAL CONTAMINATION IF IN 3-14 DAYS + OR − + + OR − +
FIG. 1

2. Take another 24 cans in the same manner after the line has been in operation for from two to two and one-half hours without extended shutdown periods and cool as indicated for the first sampling.

3. If two or more lines are in operation, it is not suggested that 24 cans be taken from each line. A total of 24 cans from all lines at each sampling period should be sufficient. However, if more than six lines are operated, take at least four cans from each line.

OBSERVATIONS FOR SPOILAGE:

All sample cans should be marked in some convenient manner for identification as to day and period, and should be incubated in an area where the temperature will not drop below 85° F. nor exceed 110° F. The cans should be observed daily for swells. If spoilage contamination with gas producers is high, a significant number of swells should appear within two or three days. In some instances, it is possible that only flat sour spoilage may occur. At the end of five days, open and taste one-half of the samples from the first period to determine whether flat sour spoilage has occurred. At the end of 10 to 14 days, open the remaining flat cans from both periods, and taste to determine whether there is flat sour spoilage. Record the occurrence of swells and flat sours on a card especially drawn up for the purpose.

INTERPRETATION OF RESULTS:

If spoilage does not occur in the can samples from either sampling period after the 14-day incubation, the bacteriological condition of the equipment and the efficiency of the clean-up may be regarded as satisfactory for the day represented.

If there is high spoilage in the first samples followed by little or no spoilage in the second samples, this is an indication of an overnight development of spoilage bacteria which entered the product during the first part of the day's run. In other words, this contrast means that at the start of the pack, excessive numbers of spoilage bacteria were present in the equipment and were gradually washed out by the tomato juice. Should this situation develop, the bacteriological condition of the packing lines would be considered unsatisfactory, and a more rigorous attention to clean-up details should be inaugurated.

Significant spoilage in both the first and second lots of samples indicates a persistent source of spoilage contamination, and the canner should make a detailed search for "pockets" in the equipment. If he cannot improve the situation by his own efforts, he should consult some qualified laboratory. This situation never has been encountered, but it should be considered in any test procedure.

This "practical" method of control has the disadvantage that results are not available in a short time, but repeated sampling will give a basis for an estimate of the usual condition of the plant during the early part of the pack. If conditions are hazardous, that fact should be obvious in five days or less. It has the advantage of its simplicity and of its requiring no laboratory facilities. There is insurance in taking more than 24 samples, holding extra cans as storage samples. In the event of spoilage, such samples would be valuable in helping to locate lots involved; i.e., as to the day and possibly the part of day affected.

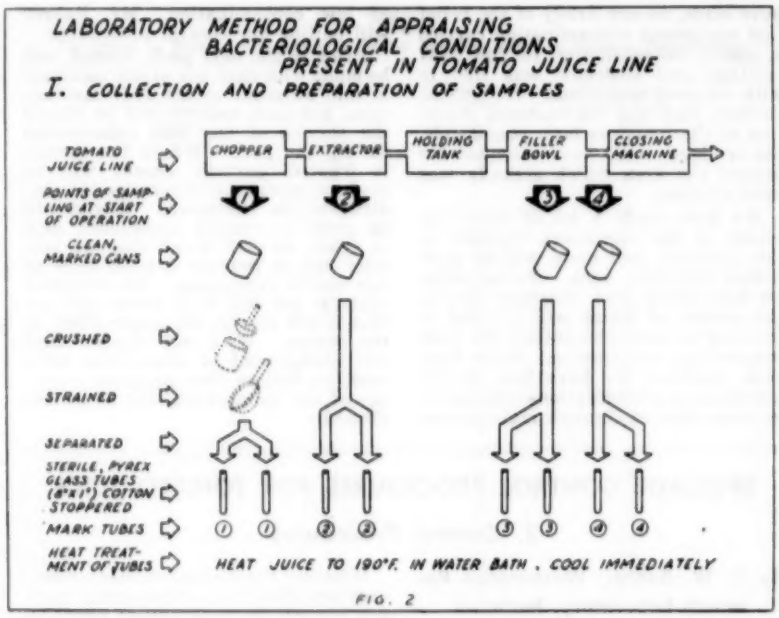


FIG. 2

Second Method Quicker, Less Simple

The second, and more specialized, spoilage control procedure makes use of some of the tools and methods employed by bacteriologists. This bacteriological method is essentially that used now by the N.C.A. for bacteriological survey purposes and by several packers of tomato juice to identify the sources of significant bacterial contamination in canning plant equipment.

In the main, the method involves the collection of samples of the tomato juice product at several stages in its preparation and the enumeration of significant bacteria present in each sample. For this purpose, three types of media are used: (1) A neutral agar medium, (2) a special acid agar medium, and (3) a tryptone broth which is stratified with agar to give anaerobic conditions after inoculation.

The neutral medium is dextrose tryptone agar containing Brom-cresol purple as an indicator. This medium gives a count of the total number of bacteria present regardless of their ability to spoil tomato juice. The count obtained serves as an index of the efficiency of the clean-up procedures. Consistently high counts suggest conditions favorable for development of the spoilage types.

The acid medium is a specially prepared proteose peptone acid agar which promotes the growth of the flat sour types of bacteria while inhibiting the growth of types not capable of producing spoilage of tomato juice. The count on this medium represents the number of *Bacillus thermoacidurans* and other acid tolerant types present, and is an index of the spoilage possibilities.

The tryptone broth medium is used to detect the presence of gas-forming bacteria of the "butyric anaerobe" type which have been responsible occasionally for swell spoilage in tomato juice.

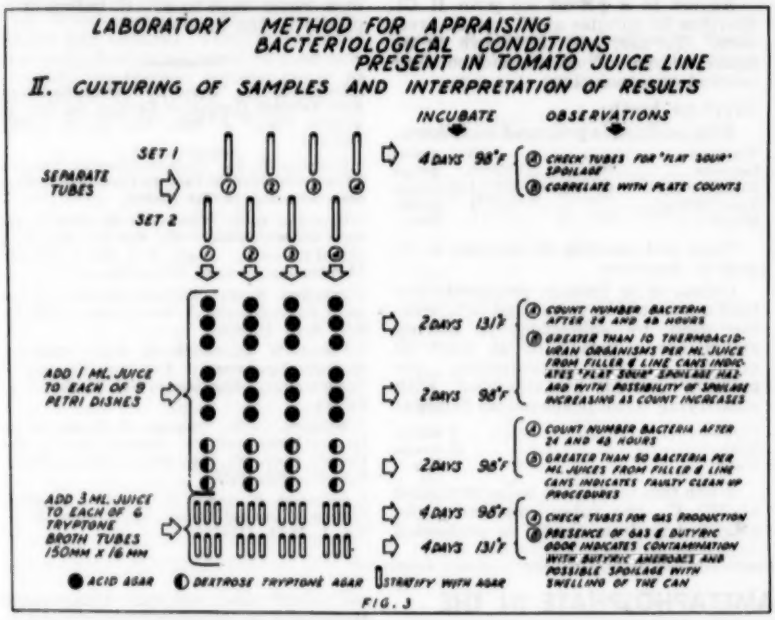
The formulas for the three media suggested are given in the appendix.

Description of Second Method

An outline of the method is shown in Figures 2 and 3, and described in detail as follows:

COLLECTION OF SAMPLES:

The samples are collected in clean-washed cans and should include chopped tomatoes, tomato juice from extractor, tomato juice entering the filler bowl, and tomato juice from the first can filled. All samples are to be taken at the start of each day's operation. Continuous control may be effected by taking additional samples throughout the day at certain selected periods. An example of this would be to take the complete set of samples


LABORATORY METHOD FOR APPRAISING BACTERIOLOGICAL CONDITIONS PRESENT IN TOMATO JUICE LINE
II. CULTURING OF SAMPLES AND INTERPRETATION OF RESULTS
INCUBATE
OBSERVATIONS
SEPARATE TUBES
SET 1
SET 2
4 DAYS 98°F
CHECK TUBES FOR "FLAT SOUR" SPOILAGE
CORRELATE WITH PLATE COUNTS
ADD 1 ML. JUICE TO EACH OF 9 PETRI DISHES
2 DAYS 131°F
COUNT NUMBER BACTERIA AFTER 24 AND 48 HOURS
GREATER THAN 10 THERMOACIDURAN ORGANISMS PER ML. JUICE FROM FILLER & LINE CANS INDICATES "FLAT SOUR" SPOILAGE HAZARD WITH POSSIBILITY OF SPOILAGE INCREASING AS COUNT INCREASES
2 DAYS 98°F
ADD 3 ML. JUICE TO EACH OF 6 TRYPTONE BROTH TUBES 150MM X 16 MM
2 DAYS 98°F
GREATER THAN 50 BACTERIA PER ML. JUICES FROM FILLER & LINE CANS INDICATES FAULTY CLEAN UP PROCEDURES
4 DAYS 98°F
CHECK TUBES FOR GAS PRODUCTION
4 DAYS 131°F
PRESENCE OF GAS & BUTYRIC ODOR INDICATES CONTAMINATION WITH BUTYRIC ANEROBES AND POSSIBLE SPOILAGE WITH SWELLING OF THE CAN
ACID AGAR
DEXTROSE TRYPTONE AGAR
STRATIFY WITH AGAR
FIG. 3

at the start of operations and again about two hours later. Following this, line samples might be taken only every two hours throughout the day. The extent and frequency of the sampling should be dependent, of course, on the number of lines in operation and the bacterial conditions encountered. If the samples cannot be examined immediately, the cans should be sealed, cooled, and kept iced.

TREATMENT OF SAMPLES:

Preparation—The chopped tomatoes are crushed with a clean spoon and strained through a clean sieve. The tomato juice from the various points is poured into correspondingly marked sterile 8" x 1" tubes, two tubes half full of juice being prepared from each sample. The tubes of juice are heated in a bath of boiling water until the temperature of the juice reaches 190° F. and then cooled immediately. The temperature is checked by inserting a thermometer into an extra tube of juice.

Culturing—After the heat treatment, which eliminates the non-significant bacterial types, the tubes are separated into duplicate sets. The tubes of juice in one set are incubated directly at 98° F. The corresponding juice in the second set of heated sample tubes is subcultured as follows:

Add one ml. of juice from each sample tube to each of nine sterile Petri plates. To six of the plates add proteose peptone acid agar and rotate the plates to mix thoroughly. After solidification, incubate three plates at 98° F. and three plates at 131° F. To the remaining three plates add dextrose tryptone agar containing Brom-cresol purple indicator, rotate the plates to mix thoroughly, allow to solidify, and incubate at 98° F.

Add three ml. of juice from each sample tube to each of six tryptone broth tubes. Stratify with agar and incubate three tubes at 98° F. and three tubes at 131° F.

Count the number of bacterial colonies on all plates after 24 hours and again after 48 hours. Check the heated juice tubes for "flat sour" spoilage and the inoculated tryptone broth tubes for gas production daily for a period of four days.

INTERPRETATION OF RESULTS:

a. Plate counts:

1. Counts of more than 10 organisms per ml. on the proteose peptone acid agar plates prepared from the filler and line samples and incubated at either 98° F. or 131° F. are a cause for concern. Although there is obviously no precise relationship between plate count and certainty of spoilage, we have, as a matter of prediction, arrived at a maximum of 10 organisms per ml. on proteose peptone acid agar (at 98° F. or 131° F.) as representing about the limit of normal contamination. Beyond that count, possibility of some degree of "flat sour" spoilage is indicated, with probable increase in spoilage with increase in count.

2. If the counts on the neutral dextrose tryptone agar plates prepared from the filler and line samples are over 50 organisms per ml., faulty clean-up procedures are indicated.

b. Anaerobic tubes:

The presence of gas having a butyric odor in any of the tubes indicates contamination with butyric anaerobes and the possibility of swell spoilage.

The count levels which are suggested are based on our survey experience and the experience of several large tomato juice packers who have used the bacteriological method over a number of years. It has been observed, however, that counts on either medium can be maintained consistently at points approaching zero under supervised clean-up.

Advantages of Bacteriological Control

The advantages of the bacteriological test over the can incubation test are twofold. First, the information is available within 24 to 48 hours, and, second, the source of contamination is located so that remedial measures can be directed to the point or points where most needed. The bacteriological method requires a certain amount of special equipment, and more important, a competent individual with bacteriological training, who has special training and aptitude for this type of work. For this reason, the bacteriological method will be more readily applied by canners already making use of bacteriological control than by those who would have to obtain the equipment and personnel.

Where possible, there is a great advantage in making use of both the incubation test and the bacteriological test. This serves as a double check not only on the bacteriological condition of the equipment, but also on the efficiency of the control procedures used. As experience is gained and conditions warrant, the incubation test may be abandoned and the rapid bacteriological test used exclusively.

Frequent Change of Code Desirable

In packing tomato juice, the can coding system should provide information that would be useful in checking the pack in the event of an occurrence of spoilage. In addition to the usual day and line designation, the code should indicate the initial period of two to two and one-half hours at the start of packing for the day. It also would be advisable to make additional coding segregations during the day.

Bacteriological tests have demonstrated that the product itself will gradually reduce an initially high contamination to a low level in from two to two and one-half hours by flushing and dilution. Should spoilage or any other difficulty be experienced, more accurate separation of affected lots can be made according to code.

As Dr. Cameron has indicated, the N.C.A. field laboratories will be in the Eastern area during the next tomato juice pack. The bacteriological method outlined above will be used to determine the condition of the equipment during packing operations and

advice will be given on control procedures.

Preparation of Tomato Juice Media

Dextrose tryptone agar containing Brom-cresol purple:

This medium is prepared as a standardized dehydrated medium and is marketed under the name of Bacto dextrose tryptone agar by the Difco Laboratories, Inc., Detroit, Mich. Because of its standardization, its use in this form is recommended. It may, however, be prepared according to the following formula:

Tryptone	10	grams
Dextrose	5	grams
Agar	15	grams
Brom-cresol purple	0.04	grams
Water	1,000	ml.

Acid agar:

Preparation: Dissolve the following in 500 ml. of distilled water:

Protease peptone	5	grams
Yeast extract	5	grams
Dextrose	5	grams
Dibasic potassium phosphate	4	grams

Adjust to a pH of 5.0 with H Cl. Sterilize 30 minutes at 15 pounds pressure. To use, add the above to an equal volume of sterile melted four percent agar solution.

Tryptone broth:

This medium is prepared as follows:

Tryptone	10	grams
Dextrose	5	grams
Dibasic potassium phosphate	1.25	grams
Yeast extract	1	gram
Water	1	liter

Tube and sterilize 30 minutes at 15 pounds pressure.

Unless it is freshly prepared, this medium should be exhausted before being used, by subjecting to flowing steam for a period of at least 20 minutes. After inoculation, the medium should be stratified with stratifying agar prepared as follows:

Tryptone	5	grams
Agar	15	grams
Water	1	liter

When this medium is to be incubated at 55° C., the tubes containing the solidified medium should be preheated in a water bath to 55° C. before it is placed in the incubator.

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THE USE OF SODIUM HEXAMETAPHOSPHATE IN THE BLANCHING OF PEAS

By J. W. Holmquist, C. F. Schmidt and A. E. Guest, Continental Can Co., Inc.

Introduction

The importance of the composition of water used for canning purposes is well known in the canning industry. Considerable work has been done on this problem, particularly with respect to the effect of calcium hardness on the quality of canned peas. Bigelow and Stevenson (1923)[1] found the degree of toughening of the skins of peas by blanching in hard water to depend on the hardness of the water and the duration of blanching. They reported that the effect was dependent upon the ratio of peas to blanch water since this controlled the ratio of calcium to peas. The effect of the use of hard water in the brine was studied and a toughening effect on the skin was found. Magnesium was found to have less toughening action than an equivalent amount of calcium. Many other workers subsequently have considered this problem and, in general, confirmed the conclusions of Bigelow and Stevenson. The cause of the toughening of the skin has been considered to be due to a base exchange process which results in the absorption of calcium by the peas.

In general, it has been found that blanching water having a hardness of more than ten grains (calculated as $CaCO_3$) will result in marked toughening of the skins of peas. In such instances, it has been recommended that the water be softened in some manner before being used for blanching or for brine. The ion exchange type of softener, such as the zeolite softener, has been rather generally adopted by those pea canners who find it necessary to soften water. Commercial practices in the use of softened water may include its use for blanching purposes, and for all, a part, or none of the brine.

Salt Blanching

Some canners having a supply of rather hard water have adopted the practice of blanching in two to four percent salt water in order to prevent the absorption of calcium and magnesium from the blanch water, and to soften the skins of peas. Laboratory work and field experience indicate that salt water blanching results in marked softening of the pea skins. Canning plants having water of a hardness in the neighborhood of 15 to 20 grains have reported good results using this method. Salt water blanching apparently prevents absorption of calcium from hard water and also results in the migration of sodium ions into the pea skins replacing an equivalent amount of calcium and magnesium ions. Pea skins resemble zeolites in their peculiar ability to permit the exchange of calcium and magnesium ions with sodium ions. The most serious objection to salt water blanching has been the excessive corrosiveness of the salt brine on the blanching equipment. Careful adjustment of the salt content of the brine also must be made to compensate for the salt pick-up by the peas during blanching.

It has been reported that sodium carbonate and sodium bicarbonate were used in the blanching of peas in the early days of canning for the purpose of overcoming the toughness of skins, and under the false impression of improving the color of canned peas. While definite softening of the skins of peas resulted from their use, the practice never was adopted generally, and was replaced by the more practical use of softened water such as that produced by zeolite softening.

Use of Hexametaphosphate Suggested

Nielson, Campbell, and Boggs (1943)[2] of the Western Regional Research Laboratory conducted a series of experiments in improving the texture of peas, lima beans, and snap beans for freezing. They found that the chemical treatment of the blanch water with sodium hexametaphosphate in excess of 0.1 percent showed a definite improvement in the tenderness of the product. Their study included consideration of the hardness of the water and a recommendation of the use of 0.3 percent sodium hexametaphosphate when the water was very hard (approximately 30 grain).

Sodium hexametaphosphate has been used very successfully to soften water for other commercial operations, and acts by forming a soluble complex with calcium and magnesium ions in the water. Advantage has been taken of the cation sequestering ability of polyphosphates in the removal of pectin from apple pomace and citrus pulps (Baker and Woodmansee, 1944)[3]; and sodium hexametaphosphate has given especially good results in increasing the yield of extracted pectin. In the extraction of pectin the polyphosphates have an initial deionizing effect on the calcium which they

have removed from the pectin (Baker and Woodmansee)[3]. More recently, Baker and Gilligan, (1947)[4], reported that polyphosphates could be used successfully to thicken tomato sauce as the result of greater extraction of pectin during the preparation.

Experimental

Some experiments were made in the Continental Can Company laboratories to secure basic information on the effect on sodium hexametaphosphate in the blanching of peas. All such experiments reported here were carried out in the following manner: 100 gram samples of peas were blanched in 500 cc. of boiling solution for five minutes and cooled and rinsed in running tap water. The blanched peas were packed in jitney cans (202 x 214) with a salt and sugar brine prepared with distilled water. The cans were processed at 240° F. for 25 minutes. Examination for toughness by a chewing test was made after three days' storage. The samples were rated numerically for toughness in relation to a control blanched in distilled water. Hard waters were prepared by adding known amounts of calcium and magnesium chlorides from standard solutions. Sodium hexametaphosphate was added from a concentrated stock solution.

The dosage of sodium hexametaphosphate was based on the following equation:

$$Na_6(PO_3)_6 + 2Ca^{++} = Na_2(Ca_2P_6O_{18}) + 4Na^+$$

which shows that one mole of Na hexametaphosphate is equivalent to two moles of calcium or of magnesium. The texture of canned peas produced by blanching in water containing different amounts of calcium, alone and combined with the equivalent, one-half the equivalent, and double the equivalent quantities of sodium hexametaphosphate, then was tested.

Table I shows the composition of the different solutions used and indicates, in column 3, the results on the texture of canned peas.

It will be noted that the optimum results were obtained when the amount of sodium hexametaphosphate used was chemically equivalent, based on the equation previously given, to the amount of calcium used. When this amount was doubled, the peas were softened still further, but the brine became cloudy and tended to form a gel.

Further laboratory tests were made in the manner previously described to determine the effect on the texture of the canned product when the peas were blanched in solutions of varying calcium content to some of which had been added $Na_6(PO_3)_6$, to others NaCl and to still others $NaHCO_3$ in varying amounts. The experiments made and the results on the texture of the canned product are indicated in Table II.

Table I

Texture of Canned Peas Produced by Blanching in Hard Water and the Effect of Additions of Sodium Hexametaphosphate

BLANCHED 5 MINUTES AT 210° F.
100 GRAMS PEAS TO 500 C.C. OF SOLUTION

$CaCO_3$ hardness p.p.m.	Sodium hexametaphosphate p.p.m.	Texture rating 0 = soft 10 = hard	Brine Gelling	Brine Clouding
0	0	4	–	–
100	0	5	–	–
100	160	4½	–	–
100	320*	3½*	–	–
100	640	2½	–	+
100	1280	1½	+	+
200	0	7	–	–
200	320	4	–	–
200	640*	3½*	–	–
200	1280	2½	+	+
400	0	8	–	–
400	640	6	–	–
400	1280*	3½*	–	–
400	2560	1½	+	+

* Values underscored represent theoretical equivalent values of calcium and sodium hexametaphosphate.

Table II

Effect of Sodium Chloride, Sodium Bicarbonate, and Sodium Hexametaphosphate on the Texture of Canned Peas Produced by Blanching in Hard Water

BLANCHED 5 MINUTES AT 210° F.
100 GRAMS OF PEAS TO 500 C.C. OF SOLUTION

$CaCO_3$ hardness p.p.m.	NaCl %	$NaHCO_3$ p.p.m.	Sodium hexametaphosphate p.p.m.	Texture rating 0 = soft 10 = hard
0	–	–	–	3
100	–	–	–	4
200	–	–	–	6
400	–	–	–	7
800	–	–	–	8
200	1	–	–	4½
200	2	–	–	4½
200	4	–	–	3
200	5	–	–	2½
400	1	–	–	5½
400	2	–	–	5
400	4	–	–	3½
400	5	–	–	3
200	–	168	–	5½
200	–	336*	–	5*
200	–	672	–	5
400	–	336	–	6
400	–	672*	–	6*
400	–	1344	–	6
200	–	–	320	4½
200	–	–	640*	4*
200	–	–	1280	3½
400	–	–	640	5½
400	–	–	1280*	4*
400	–	–	2560	2½

* Values underscored represent theoretical equivalent.

The results show that four to five percent sodium chloride is required to overcome the toughness produced by 200 or 400 p.p.m. hardness, while double the theoretical quantity of sodium bicarbonate to combine with the calcium (672 and 1344 p.p.m. or 0.06 and 0.13 percent) did not completely overcome the toughness produced by 200 and 400 p.p.m. hardness. The presence of an equivalent quantity of sodium hexametaphosphate completely prevented the toughness produced by 200 and 400 p.p.m. hardness.

The peas blanched in the sodium chloride solution possessed an objectionable salty flavor while those blanched in sodium bicarbonate had an objectionable brackish flavor. No noticeable off-flavors of any sort have been detected in peas blanched in sodium hexametaphosphate even when excessive quantities were used.

Under the same laboratory procedure, ten different combinations of calcium and magnesium with the total hardness varying from 20 p.p.m. to 704 p.p.m. were tested alone, and in combination with the chemically equivalent quantities of sodium hexametaphosphate. Table III shows the various combinations of calcium and magnesium hardness of the water used for blanching, and the effect of sodium hexametaphosphate in overcoming the toughening effect of these combinations.

Table III

The Effect of Calcium, Magnesium, and Sodium Hexametaphosphate Combinations in Blanch Water on the Texture of Canned Peas

BLANCHED 5 MINUTES AT 210° F.
100 GRAMS OF PEAS TO 500 C.C. OF SOLUTION

$CaCO_3$ hardness p.p.m.	Ca ++ p.p.m.	Mg ++ p.p.m.	Texture rating No sodium hexametaphosphate	Sodium hexametaphosphate	Sodium* hexametaphosphate p.p.m.
0	0	0	3	–	–
20	8	0	3½	–	–
220	8	40	3½	–	–
100	40	0	4	3	400
226	50	25	4	3	750
339	50	50	5	3	1100
187	75	0	5	3	600
239	75	25	5	3	950
392	75	50	5	3	1300
249	100	0	5½	3	800
351	100	25	6	3	1150
454	100	50	6	3	1500
499	200	0	7	3	1600
601	200	25	6	3	1950
704	200	50	6½	3	2300
102	0	25	3	–	–
205	0	50	4	–	–
410	0	100	5	–	–

* These values represent theoretical quantities of sodium hexametaphosphate to react with the calcium and magnesium present.

The results show that the addition of a chemically equivalent quantity of sodium hexametaphosphate prevents the toughening effect of the various blanch solutions. In no case were any adverse effects such as turbid or gelatinous brine observed.

Tests were conducted to determine the effect of blanching successive batches of peas in the same blanch water containing sodium hexametaphosphate. In this experiment, Alaska peas, in the proportion of 30 ounces of peas to approximately one gallon of water, were blanched in successive batches five minutes at 200° F. in a solution containing initially 0.2 percent sodium hexametaphosphate. After the initial blanch the concentration was maintained at approximately 0.1 percent by replacement of sodium hexametaphosphate when analysis showed the need. Tap water of 7- to 8-grain $CaCO_3$ hardness was used. The calcium content of the blanch solution was determined after each successive blanch and is shown in Table IV.

Table IV

Calcium Pick-Up of Blanch Water Containing Sodium Hexametaphosphate

BLANCHING SOLUTION—200° F.—TAP WATER INITIALLY 8 GR. $CaCO_3$ HARDNESS

Successive blanch number	Approximate % $Na_6(PO_3)_6$ in blanching solution	Gallons water	Calcium as $CaCO_3$ gr. per gallon
1	0.2 (initial dose)	1.0	21
2	0.1	0.96	42.5
3	0.1	0.92	41.6
4	0.1	0.80	59.0
5	0.1	0.76	68.0
6	0.1	0.72	64.1
7	0.1	0.69	71.0
8	0.1	0.65	76.0

The results indicate that blanching peas in sodium hexametaphosphate solutions in excess of that required for chemical combination with the calcium hardness of the water results in migration of calcium from the peas. There was no significant difference between the texture of the peas in successive blanches, although the actual calcium content of the blanch water increased. This also indicates that sodium hexametaphosphate effectively combines with the calcium removed from the peas to exert a deionizing effect on the calcium.

For effective results, the laboratory studies indicated that the amount of sodium hexametaphosphate to be added to the blanch water is dependent on the total hardness of the water used for blanching peas. The amount can be calculated on the basis of one mole of sodium hexametaphosphate being equivalent to two moles calcium or magnesium. For convenience, the following formula may be used in determining the amount of sodium hexametaphosphate to be used when the total hardness of the water is known.

P.P.M. hardness as $CaCO_3$ x 3.1 = P.P.M. $Na_6(PO_3)_6$

or

P.P.M. hardness as $CaCO_3$ x 0.041 = Av. Oz. $Na_6(PO_3)_6$ per 100 gallons of water

Table V gives some illustrations of the quantities of sodium hexametaphosphate required per hundred gallons of water for different levels of hardness.

Table V

Quantities of Sodium Hexametaphosphate Required to Combine with Various Levels of Water Hardness

Total Hardness as $CaCO_3$ p.p.m.	Sodium Hexametaphosphate p.p.m.	Oz/100 gallons
100	310	4.1
200	620	8.2
300	930	12.3
400	1240	16.4
500	1550	20.5

Field Studies

The fundamental information developed in the laboratory with regard to the quantity of sodium hexametaphosphate required to combine with the calcium carbonate hardness was used as a basis for treatment of the blanch water in several canneries.

Cannery No. 1. Since the water supply used for canning peas at this plant was very hard (24 grain as $CaCO_3$), the toughening effect of the calcium present was quite apparent. A preliminary test pack of Alaska peas was made using various quantities of sodium hexametaphosphate in the blanch water. The peas were kettle-blanched five minutes at 200° F. in water containing various amounts of sodium hexametaphosphate. Control samples were blanched in regular factory water. After blanching, the peas were washed and filled into standard No. 2 cans, the fill completed with regular factory brine, cans closed and processed 35 minutes at 240° F. In addition, one sample was prepared by blanching in untreated water but using 0.3 percent sodium hexametaphosphate in the factory brine. The results are tabulated in Table VI.

Table VI

Experimental Pack Alaska Peas Blanched 5 Minutes at 200° F. in Water Containing Various Amounts of Sodium Hexametaphosphate

Sodium Hexametaphosphate in Blanch Water, %	Effect on Texture
Control	Firm with tough skins
0.1%	Very slightly more tender than controls
0.2%	Considerably more tender than controls
0.3%	Soft in texture, but not objectionable since liquor still reasonably clear
0.3% in brine only	Soft and mushy, brine gelatinous

The above data indicates that the use of sodium hexametaphosphate in blanch water or in brine resulted in marked softening of the pea skins and cotyledons. Because of the extreme softening which took place in the sample to which the sodium hexametaphosphate had been added to the brine, it was decided to forego any further tests by this method of treatment.

A preliminary commercial test was attempted using approximately 0.2 percent sodium hexametaphosphate solution in a conventional reel-type blancher. The results confirmed the experimental packs, as the peas blanched in the 0.2 percent sodium hexametaphosphate solution were considerably more tender than peas blanched in untreated water.

Continuous commercial operations for periods up to four hours produced effective softening of both sweet and Alaska type peas. Treatment of the blanch water was accomplished by adding to the water in a reel-type blancher the initial theoretical quantity of sodium hexametaphosphate necessary to combine with the calcium hardness. The sodium hexametaphosphate in the blanch water which was lost due to chemical combination with calcium and magnesium and to decomposition was replaced by the addition of a stock solution containing one pound of sodium hexametaphosphate per gallon of water. An effort was made to dose the blancher continuously with the stock solution so that a uniform concentration of 0.1 to 0.15 percent was maintained.

Avoiding Over-Dosage

The control of sodium hexametaphosphate in the blancher water was based on a colorimetric test. The method of estimating the quantity of sodium hexametaphosphate in the solution was based on the fact that iron forms a stronger complex with this salt than with thiocyanate. Sodium hexametaphosphate causes fading of the usual red iron thiocyanate complex, and the color change can be used as a basis for estimating the concentration of freshly prepared hexametaphosphate solutions (Wirth, 1942)[5]. Convenient color cards were developed for plant control purposes.

The experimental packs under commercial conditions resulted in a decided improvement in the quality of peas with respect to toughness of skins as well as cotyledons. It was demonstrated that accurate control over the addition of sodium hexametaphosphate was necessary for effective results. This was especially true in avoiding over-dosage, which results in cloudy, viscous brine and, in extreme cases, in soft, mushy peas.

Cannery No. 2. An exploratory pack of sweet peas of the Prince of Wales type was made using so-

dium hexametaphosphate, sodium septametaphosphate, sodium carbonate, and sodium bicarbonate in the blanch waters. The pack was made using the plant water supply having 16 grain calcium hardness. Peas were kettle-blanched five minutes at 200° F. in the experimental blanch waters, washed, filled into No. 2 cans, fill completed with regular cannery brine, cans closed and processed 30 minutes at 248° F. The results are tabulated in Table VII.

Varying Results

The test packs showed that in this case, blanching in 0.2 percent sodium hexametaphosphate gave the best results, although 0.1 percent showed a definite improvement in the texture of the peas. Sodium hexametaphosphate of 0.5 percent strength resulted in excessively sticky brine and mushy peas. Sodium septametaphosphate in blanching solutions of comparable strength resulted in a greater degree of softening; for instance, 0.1 percent sodium septametaphosphate in the blanch water was approximately equal to 0.2 percent sodium hexametaphosphate in tenderizing effect. However, sodium septametaphosphate resulted in a slight objectionable "off" flavor and slightly more turbid brine. The addition of sodium carbonate over a five-fold range of concentration did not soften the peas appreciably. However, 0.4 percent resulted in a degree of tenderness comparable with 0.2 percent sodium hexametaphosphate, but the brine was of a dark, unnatural color which later became quite turbid on storage. No appreciable effects were noted with the use of sodium bicarbonate in the strengths of 0.1 percent and 0.25 percent.

It was concluded that under the conditions of this test 0.2 percent sodium hexametaphosphate in the blanch water (16-grain hardness) gave the best results in tenderizing the peas, while sodium septametaphosphate, sodium carbonate, and sodium bicarbonate were not considered satisfactory.

Cannery No. 3. In some areas, canners have difficulty with tough, chewy skins in certain varieties of sweet peas even when using softened water for blanching and brining purposes. The usual procedure in such cases has been to increase the process in order to overcome the toughness of skins. In some instances, blanching in salt water (two to three percent) in combination with increased process times and temperatures has been found effective. Experimental packs were conducted under commercial conditions to determine whether blanching peas with inherently tough skins in sodium hexametaphosphate solutions in softened water would effectively tenderize the skins.

The experimental packs indicated that the sodium hexametaphosphate blanching treatment resulted in peas as tender, when using a process of 25 minutes at 245° F., as those produced by blanching in two percent softened salt water and processing 40 minutes at 245° F. It again was demonstrated that excessive dosage resulted in excessive softness and viscous brine with both very young and mature peas. In this particular test 0.1 percent sodium hexametaphosphate appeared to give optimum results.

Discussion

While the experimental work shows that the use of sodium hexametaphosphate may be of considerable value when blanching peas in hard water, it also indicates that careful control of the concentration of this compound is necessary in order to avoid undesirable conditions such as excessive cloudiness, viscosity, or even gelling of the brine. These conditions may occur if the concentration of sodium hexametaphosphate in the blanch water becomes too high.

Hexametaphosphate never should be used in the blanching of peas unless the concentration is carefully controlled. As stated previously, a colorimetric test has been developed for testing the concentration, and the test should be conducted by a responsible and reliable person, preferably one technically trained. The hazards involved with over-treatment of the blanch water must be understood clearly by management and operating personnel. It is suggested that if this treatment is considered by any canner, it should be carefully tested on experimental packs before commercial operations are attempted.

Sufficient work has not been done on the final mineral composition of peas blanched in waters treated with sodium hexametaphosphate to determine whether appreciable quantities of this compound are absorbed, nor has consideration been given to the compliance of peas so treated with existing Federal standards. Further investigation of these points should be made before commercial application of this method is attempted.

Table VII

Experimental Packs of Prince of Wales Type Peas Using Sodium Hexametaphosphate, Sodium Septametaphosphate, Sodium Carbonate, and Sodium Bicarbonate in Blanch Water (16 Gr. $CaCO_3$ Hardness)

	Blanch water treatment	Texture rating 0 = soft 4 = firm	Brine
Control	None	4	Normal
0.1%	Sodium hexametaphosphate	3½–4	Normal
0.2%	Sodium hexametaphosphate	3	Normal
0.5%	Sodium hexametaphosphate	1½	Viscous
0.1%	Sodium septametaphosphate	3½	Normal
0.2%	Sodium septametaphosphate	3	Normal
0.3%	Sodium septametaphosphate	1	Viscous
0.08%	Sodium carbonate	4	Normal
0.16%	Sodium carbonate	3½	Sl. dark
0.4%	Sodium carbonate	3	Dark brine
0.1%	Sodium bicarbonate	4	Normal
0.25%	Sodium bicarbonate	3½	Normal

Summary

1. Laboratory and field studies have shown that the addition of sodium hexametaphosphate in amounts chemically equivalent to the amounts of calcium and magnesium in the blanch water will result in a definite softening of the skins of peas.

2. It is indicated that the addition of amounts of sodium hexametaphosphate in excess of the quantity chemically equivalent to the hardness results in further softening of the peas.

3. The addition of an excessive amount of sodium hexametaphosphate results in a corresponding degree of oversoftness of the peas, and cloudiness to viscous brines.

4. Careful control of the concentration of sodium hexametaphosphate in the blanch water must be maintained in order to obtain satisfactory results.

5. Compliance with existing Federal standards of canning peas which have been blanched in sodium hexametaphosphate solutions has not been considered in this study.

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DEVELOPMENT OF NEW CANNED PRODUCTS

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Nearly every canner, after the season's pack is over and between conventions and preparing for the next season, has considered "adding to his line" as a means of increasing volume; that is, introducing new canned products, either new to his particular operations, or new to the industry as a whole.

This paper is a consideration of the main factors which a canner needs to consider seriously in order to be successful in such a venture. That serious planning is required is without question. In addition, since most canners do not have large development and research organizations, the canner himself must fully understand the detailed problems involved. First and most important of all is the question, "Is there a place for the new product?". For this an analysis of the market, competition, distribution and consumers' preference is essential. Next, "Are raw materials as well as adequate equipment, housing and labor available or procurable?". Finally there is the actual development of the product itself from a recipe or formula, through the selection of processing and sterilization procedures, to production. All of the above factors are important. Which should receive greater attention, however, depends upon the canner's individual circumstances as well as the degree of "newness" of the product in question; that is, what form the new item will take. Generally there are three variations:

(1) ***Modification of staple items slightly so that they become specialties.*** This obviously is the least venturesome approach. It merely means the adding of one or two additional ingredients and/or flavors to a standard fruit or vegetable. Thus, a green bean and potato canner may combine the two and with the addition of salt pork produce a "Southern Dinner"; Mexican style corn can be made by adding peppers to whole grain corn, or onions can be added to tomatoes. This gives the product a mark of distinction over competitors and also increases general acceptance by creating more variety and broader appeal. Such modifications can be made for practically all canned foods. This obviously does not mean that a canner should endeavor to specialize his whole pack. As we sometimes say, many people "do not like onions", but the chances are that a canner's modified product will appeal to enough people for them to ask for his brand over others and also increase consumption generally over non-canned foods. Such modifications, naturally, should be carried out with caution, but experience has shown that where a canner specializes with discretion, increased volume results. Generally, this approach presents few technical difficulties.

Slight modification in processing may be necessary and the shelf-life needs to be watched since the blend may show changes in storage which are not encountered with each product alone. Production problems are at a minimum since little additional equipment is required. Likewise, because of the small added investment, the market and consumer acceptance can be explored with little risk.

(2) ***Expansion to items already in the market in some quantity.*** Here the fundamental consideration is the market and competition as well as the availability of new material, equipment, labor, etc. The technology of production of such staple foods is generally known, but careful consideration should be given to improved methods of processing and handling which will decrease costs and increase quality.

(3) ***Formulation, development and marketing of a new canned product.*** This means developing canned goods of a new and different formulation or type which are not at present on the market or only to a very minor degree. The problems here are all inclusive. In essence, however, it is the problem of the selection of a product which can be processed economically and which will find sufficient consumer acceptance to permit profitable volume production. This selection of canned products which are ready for development has been a little-developed science or even art. However, it fittingly comes under the realm of the canning technologist and will be so considered here.

Selection of a New Product or Type Product

All of us, as well as many outside the canning industry, can think of an endless number of desirable canned products which would please the public taste if the production difficulties were surmountable. The difficulty is the proper assurance that a given product is worthy of the risk of time and money for development. We are, however, not entirely without tools or aid in reducing this risk.

Some suggested aids are:

(1) History of development of products now considered staples.

(2) Food habits and consumer preference or food acceptance.

(3) A broad understanding of the technological level of the canning industry and the limitations involved in processing given type products.

As to history, it is well known that the past generation showed a great expansion of the canning industry as a whole. This is partly accounted for by the greater acceptance of canned foods and the resulting expansion of the staple fruits, vegetables, meat, fish and milk. However, new products, e.g., new to the early '20s, have also been a considerable factor in the increased volume. These have included fruit and vegetable juices, ready-to-serve meat dishes, and other specialties such as baby food and animal food.

Acceptance of New Products

The acceptance of such new products is the result of two factors: The increased urbanization of our population and the movement of the American housewife out of the kitchen; and technological improvements in our industry which have permitted volume production of high quality, tasty, nutritious canned foods at a low selling price. When the general acceptance of a canned product by the housewife and her family is such as to make the greater inconvenience of other forms of food preparations undesirable, there is a definite swing to increased volume for that canned product.

The total food consumption per capita in the U. S. remains reasonably constant, but a tabulation of the relative consumption of canned foods today is interesting.

Percentage of Total U. S. Consumption of Food as Canned Products

Vegetables	About 25 percent
Fruits	15 to 20 percent
Milk and dairy products	About 4 percent
Fish	About 10 percent
Cereals	Practically none

To consider what products are ripe for development a canner needs only to examine the American diet and select those products which within the present technological level of the canning industry will permit sufficient and quality production to find general acceptance. At considerable risk the following are suggested as offering a fruitful field for development today: "Complete" meat meals; formulated and prepared vegetable dishes; salads —both vegetable and fruit; dairy products; breakfast foods—particularly cereals; desserts—particularly non-fruit.

As a second aid in the selection of new canned foods for development, we suggest the newly developing science of Food Habits and Food Acceptance. Much of the work along these lines until recently has been called Market Research. However, it has been relatively little developed for canned foods and the main concern has been with consumer reaction to products already on the market or consumer choice between different brands or methods of packaging.

Food Habits Important

A more fundamental approach is broad research on food habits and preferences as well as trends in food consumption. Pioneer work has been done by the National Research Council's Committee on Food Habits. Much of this work is being continued, with

the help of national and state organizations, by the Food Acceptance Division of the Food and Container Institute, U. S. Army Quartermaster Corps.

The Committee on Food Habits, through surveys within given cultural areas, has drawn together existing knowledge on food likes and dislikes and the processes of their formulation and change. This committee lists four prevailing factors influencing the American family in its selection of food: Money (and convenience of preparation), health, taste, and status (e.g., glamour attached to particular food). Obviously, the weight of these respective factors varies considerably between different regional, cultural and income groups. A canner in developing a new product should endeavor to secure the highest rating for each. Likewise, as a result of a study of food habits, a soup packer might conclude that he can increase consumption of his vegetable soup by having several flavor variations, properly labeled, over his basic formula. That is, while uniformity in flavor has been and should be a much sought-after quality, intentional variety in flavor may increase consumption by decreasing satiety.

All progressive canners should become familiar with the work of Dr. Franklin Dove of the Food Acceptance Division, Food and Container Institute. The need for research on food habits and the development of a science of food acceptance becomes obligatory under a system of nation-wide food production for mass consumption. A product which appears excellent in the region of preparation may be entirely unacceptable throughout the remainder of the U. S. The results of Dr. Dove's work will be followed by all interested in food science and technology.

Technical Basis Must be Sound

The third indispensable aid in the selection of new canned products is a broad understanding of canning technology. Any individual can think of products which would be nice if canned, but only a fully trained canning technologist can determine whether a product now offers commercial possibilities. A housewife recently asked why cake and biscuit batter is not packed into cans ready for popping into the oven. While this has been done as a refrigerated canned product, obviously, within our present knowledge, such a product cannot be heat sterilized. As canning technology develops, however, broader fields and possibilities are opened. Thus, canned cream of fine flavor was impossible a generation ago, but developments in high-short sterilization and aseptic filling have made it a commercial reality today. Likewise, other techniques such as acidification, vacuum packing, and agitating cooking now offer means of producing acceptable products previously impossible with processes adequate with regard to commercial sterility. Before a canner or technologist rules out a given canned product as being out of the question, he should carefully scrutinize the field as to whether recent technological advances now permit the "impossible."

Technical Development of New Products

Once the canner has selected a type product which, with sufficient raw material, can be produced economically and offers a good chance of finding consumer acceptance, he is ready for its technical development. The creation of any fine food product is initially a work of art, but the practical details for commercial production must be worked out in the kitchen, laboratory, pilot plant, and the factory.

First there is the selection of a recipe which is appealing and lends itself to commercial canning operations. There are various approaches to the selection of a proper recipe or creating a new product, and the art of cookery is endlessly fascinating. It would behoove any canner, who is planning to develop new products, to have someone in his organization who not only "likes to cook" but has a definite "flair" for experimental cookery. Such a person might be a home economist, a food technologist, or anyone in the organization who has the time to develop the hobby of cookery. Some organizations retain well-known chefs as consultants to originate the recipes. In any event an experimental kitchen must be set up with a well stocked library of cook books. The resulting products can be tried by a testing panel throughout the day or at special luncheons.

Next is the modification of an acceptable recipe through the small batch to commercial formula. This is the development from the sauce-pan batch to cooking kettles—from "teaspoons" and "dashes" to pounds and ounces. As one becomes experienced in experimental cookery, he soon learns to use grams and cubic centimeters or ounces from the start. Here, there is the danger that the mechanical approach may destroy the creative touch of the cook. This can be solved by measuring or weighing out a given quantity of ingredients, adding to taste, and then reweighing the unused portion. The difference is the formula. Once the small batch has been approved, further adjustment may be necessary due to relative availability of materials and costs in commercial quantities. Likewise, a change in balance of flavors, thickening agents or other ingredients is often necessary due to the longer heat-time cycle involved in the larger batches. This longer heating introduces the most critical stage in the development of the product. A product which is exceptional when prepared in the kitchen may show radical changes in flavor, color, texture and stability in larger size processing and storage. Here a technologist's knowledge of the properties of all the new materials, and how they can be modified to produce the desired results, is of great value.

This brings us to the question of the proper process. The sterilizing process that will be required should receive early consideration in the development of the new food specialty. A tentative process of about the same time and temperature that will probably be required commercially should be adopted so that the effect of processing on the product can be observed and necessary compensating changes in the formula made. The final determination of the process to be used commercially cannot be made until the product is completely developed since formula changes may affect the processing requirements. The pilot plant stage is, therefore, the time to finally determine the commercial process.

Determining the Process

In determining a process it must first be decided from the nature of the product what types of organisms are capable of causing spoilage and must therefore be destroyed in processing. For example, if the pH is 4.5 or less, the resistant spore-forming bacteria can, in general, be disregarded and a process at 212° F. or possibly lower may be used, while if the pH is higher, processing in pressure retorts must be done to obtain a process sufficiently severe to destroy resistant spores. If the pH is such that spore-forming bacteria must be destroyed, the thermal death time in the product of the most resistant organism which it is necessary to destroy must be known. This can often be arrived at by analogy with the resistance of the spores in other similar products which have been used in previous thermal death time determinations, or it may be necessary to make such a determination. Any process must have a sterilization value sufficient to destroy the spores of *Clostridium botulinum*, and in many cases the process must be even more severe to destroy the spores of more resistant spoilage organisms. Since thermal death-time work is time-consuming, early consideration should be given the problem.

With the thermal resistance of the bacteria determined either by analogy or by experiment, it remains to find the rate of heat penetration in the product for the can size to be used. This is done by reading the temperature at the slowest heating point inside the cans by means of thermocouples and a potentiometer while the test cans are being processed in a retort.

The heat penetration data and the thermal death time of the organisms are then used to solve mathematical equations to determine the process time and temperature which will yield a sterilization value sufficient to destroy the organisms. Since the amount of sterilization which occurs

while the temperature of the product in the cans is rising or falling may be of more significance than the time that the temperature remains at its maximum, the calculation of processes must involve the application of higher mathematics. The development of methods of process calculation has been a major factor in putting processing on a firm scientific basis.

Checking the Process

Where it is necessary, because of quality considerations, to keep the severity of the process at a minimum, the calculation of a process should be followed by an inoculated pack which will serve as a check on the work. This involves placing bacterial spores of known heat resistance in a series of cans of the product and processing groups of these cans for various times above and below the calculated process. The cans are then incubated and the various lots observed for the occurrence of spoilage. Incubating cans which have not been inoculated are of little value in evaluating a process.

Some products, for the sake of quality, are given processes more severe than are necessary to insure against spoilage, but the most general problem is to provide an adequate sterilizing process without causing severe alteration of the product. Proper formulation can increase stability to heat, but not infrequently it is impossible to reconcile sterilization requirements and quality. This requires a re-evaluation of the problem and even perhaps an abandonment of the product as such.

Unless the canner has both the necessary facilities and technical personnel experienced in the work of process determination, he should very early seek the advice and assistance of a qualified laboratory connected with the canning industry regarding the processing of his product. Though it may sometimes be discouraging, the advice of experienced, technically trained men should be accepted in processing problems, for to follow any other course would be to disregard the work over the past quarter century which has established processing on sound scientific principles and made canned foods the safe, acceptable products which they are today.

Effect of Storage

Once a satisfactory product is obtained with an adequate process, samples should be stored at room temperature for observation of chemical and physical changes which are likely to occur in time. As indicated above, such storage without inoculation or heat penetration data is of little value in determining whether a product will keep biologically, but these storage tests are important in indicating changes in color, flavor, texture, stability, etc. After a few weeks of storage, prediction of shelf-life can usually be made from the properties of the ingredients and analogy with similar products. Such storage tests can also give data on the type of container, lacquer, metal, etc., which should be used. Your can supplier's research representative can be of material assistance in this selection of the proper container.

The final step in the actual development is a trial factory run to iron out the production bugs and to obtain adequate samples for sales, research, and other needs. This trial production run also permits better calculation of yields and costs and indicates minor changes in formula as well as possible changes in equipment in the light of the larger batches. Even after the new product has successfully passed the above hurdles and is in production it must be watched closely for production flaws and sales results. A product, in order to continue to sell, must be of lasting value, not just new.

In conclusion, although tomorrow may not be exactly the same as yesterday, it is felt that the same general conditions which have permitted the healthy expansion of new canned items in the past still operate, and the years ahead will see a continued growth of new and different canned food items. As always, however, caution and technical know-how are indispensable, and like most everything today, "it won't be easy."

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